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Yield and quality of some grass-legume mixtures in response to N, P, and K fertilizers in the central interior of British Columbia

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Yield and quality of some grass-legume mixtures in response to N, P, and K fertilizers in the central interior of British Columbia

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The dots on the map represent
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ABSTRACT

There is a need for more information on how forages are going to respond to applied fertilizer when grown on soils in the Central Interior of B.C. In addition, knowledge of which nutrients are limiting is essential to prevent the application of fertilizer elements that are not required. Forages in the Central Interior of B.C. all respond to applied nitrogen fertilizer and some are known to respond to phosphorus and sulfur. In this study the crop response to increasing rates and split applications of nitrogen was determined at 3 locations. A third part of the test determined crop response to nitrogen, phosphorus, potassium or a mixture of micro-nutrients which included copper, zinc, boron and molybdenum.

Use of nitrogen fertilizer increased forage dry matter yields by 100-200% compared to fields which received no nitrogen fertilizer. Nitrogen fertilizer did not increase the quality as the crude protein and percent digestibility both decreased with increasing amounts of nitrogen at moderate rates. Split applications of nitrogen increased yields between 2 and 5% over single spring applications. These small increases do not warrant two separate applications. The minus trial showed that nitrogen was the most limiting and, therefore, the most economical fertilizer element to apply. Phosphorus was also limiting but to a lesser extent. Potassium and the micro-nutrients tested were not deficient.

Economically the application of fertilizer N is very sound in that the expected returns from the applied fertilizer will more than pay for the extra input costs. At relatively low applications of N fertilizer (56 kg N/ha) not only is there more forage produced per hectare but also there is in increased economic return of between $26 to $37 per hectare after accounting for the additional costs. This is something that should be considered seriously.

RÉSUMÉ

Il est nécessaire d'obtenir de plus amples renseignements sur la façon dont les cultures fourragères de la région intérieure centrale de la Colombie-Britannique réagissent à l'apport d'engrais. Il est aussi essentiel de connaître les éléments nutritifs limitants afin d'éviter l'épandage d'éléments dont on n'a pas besoin. Toutes les cultures fourragères de la région intérieure centrale de la Colombie-Britannique réagissent à l'apport d'engrais azoté et certaines à l'apport de phosphore et de soufre. Dans le cadre de la présente étude, on a déterminé à trois endroits les effets de la hausse de la concentration d'azote et du dédoublement des épandages. Dans une troisième partie de l'expérience, on a évalué la réaction des cultures à l'apport d'azote, de phosphore, de potassium ou d'un mélange d'oligo-éléments dont du cuivre, du zinc, du bore et du molybdène.

Les engrais azotés ont permis d'augmenter de 100 à 200 % le rendement en matière sèche des cultures fourragères comparativement à celles qui n'ont pas reçu cet engrais. La qualité des cultures n'était cependant pas meilleure, puisqu'une augmentation modérée de la concentration d'azote a provoqué une diminution de la teneur en protéines brutes et du pourcentage de matières digestibles. Le dédoublement des apports d'azote a permis d'augmenter le rendement de 2 à 5 % en regard d'un apport unique au printemps. Ces faibles hausses ne justifient donc pas la division des apports. En éliminant l'azote, on a pu démontrer que cet élément est le plus limitant et on en a déduit que l'engrais azoté est l'élément fertilisant le plus économique à appliquer. Le phosphore aussi est limitant, mais à un degré moindre. On n'a pas décelé de carence en potassium ou en oligo-éléments.

Du point de vue économique, l'apport d'engrais azoté est une pratique saine puisque la valeur de la hausse de rendement dépassse les coûts supplémentaires qu'occasionnent les facteurs de production. L'apport d'une concentration relativement faible (56 kg N/ha) d'engrais azoté entraîne une hausse de la quantité de fourrages produits ainsi qu'une augmentation de 26 à 37 $ l'hectare du rendement économique après déduction des coûts supplémentaires. Il s'agit donc d'une possibilité qu'il serait bon d'examiner avec soins.

TABLE OF CONTENTS

List of Appendixes

List of Figures

List of Tables

Acknowledgements

This report is the direct result of work started by Mr. Mike van Adrichem and carried on by the staff of the Prince George Experimental Farm when he left. We would like to thank the staff for their input in the field, laboratory and the tabulation of the results. A special thank you to Mrs. Ann Robertson for doing much of the typing and to Dr. J.A. Robertson and Ms. Sandra Kinsey for editing the manuscript. We would also like to thank the producers Mr. and Mrs. Leroy Taylor and Mr. and Mrs. Terry Storey for the use of their land and facilities to conduct the fertilizer trials.

INTRODUCTION

The high cost of fertilizer continues to increase interest in soil-testing even though in the last few years fertilizer prices have dropped and remained fairly constant. Determining the response of plants to applied fertilizer is one way to obtain a better understanding of the soil nutrient requirements. To grow higher yielding, better quality crops and help ease the cost-price squeeze of the high cost from applied fertilizers, determination of nutrient requirements and expected returns should be considered. If field correlations for the area were available it would make the soil-test more reliable. The main purpose of these field tests was to determine how well a forage crop responds to applied fertilizer.

During 1975-1980 soil fertility and crop response research was conducted by the Prince George Experimental Farm on grass-legume stands to collect more local information on plant response to fertilizer. The information collected consisted of grass-legume response to various rates and times of nitrogen (N) application. The major limiting nutrient in most soils is nitrogen and that is also the case in the Central Interior of B.C. Generally the amount of nitrogen in the soil that is available for plant growth is low and economic responses are expected to applied N fertilizer. The other nutrient levels and their relationships to plant response are not as clearly defined. Phosphorus is limiting in a number of soil types and sulfur is known to be deficient in many of the soils. The potassium levels are generally adequate except for very coarse textured soils. Little is known about micronutrients. Another part of the trial determined the responses of the same crop to N, phosphorus (P), potassium (K), and the minor elements boron (B), copper (Cu), zinc (Zn), and molybdenum (Mo) in one test.

Three types of field trials were conducted: (1) increasing N fertilizer rates, (2) single versus split nitrogen fertilizer applications, and (3) a minus fertilizer trial. These field trials were conducted on 3 different soil types in Central B.C.: Smithers Doughty clay, Smithers Driftwood loam and Prince George Pineview clay to determine crop response.

Soils and the Landscape

The main area of Central B.C. is made up of the Nechako Plain. The topography of the interior plateau consists of large rolling upland areas separated by broad valleys. The area was glaciated and is covered by a glacial deposit which has been modified by subsequent lake formation and erosion. Coarse materials were deposited by the melt waters before reaching the lakes. The largest lacustrine basins are found around Fort St. James, Vanderhoof and Prince George and are the location of much of the present agricultural land (Valentine et al. 1978). The soils are mainly Gray Luvisols with low organic matter contents and a leached surface horizon (Ae). The leached surface horizon is weak in structure and overlies a much finer and denser layer of accumulated clay (Bt) layer which resists water and root penetration. In spring and during periods of

excessive moisture, the surface horizons can become saturated and are susceptible to erosion. The soils developed from glacial till and outwash are usually coarser and much more variable in texture.

The Doughty and Pineview soil series are heavy clay soils developed from lacustrine deposits. The Pineview soil has some serious defects such as poor soil moisture relationships, fine texture, very compact B horizon, low organic matter content, and low soil temperatures, especially in the spring. Percolation is greatly reduced by the slowly permeable subsoil. These limitations make it much more difficult to farm these soils (Lavkulich 1982). Similar problems are encountered on the Doughty clay soils. The Driftwood soil series consists of medium to light textured soils developed on glacial till deposits. Textures of surface materials vary from gravelly sandy loam to clay loam. Surface drainage is quite good while internal drainage is very slow due to the dense compact subsoil. The Smithers soils are Dark Gray Luvisols while at Prince George the soil is a Gleyed Gray Luvisol.

Luvisolic soils lack many favourable physical and chemical properties for crop production. Often they cake and bake and are subject to crusting under drying conditions. These soils also pulverize when tilled, are slow to take in water, often poorly aerated, and root penetration into the B horizon is often difficult. Poor chemical properties are primarily due to the lack of organic matter or humus and therefore the ability to supply nitrogen is low. This lack of organic matter also has a detrimental effect on soil tilth and farming. Farming practices which require a lot of annual tillage are not that well suited to these soils.

Climate and Weather Data

The climate of north-central B.C. can be described as continental as much of the influence of the Pacific Ocean is lost because of the Coast Mountains acting as a barrier. In general, the summers are short and warm, and the winters long and cold. The precipitation is medium to light (400-750 mm) and fairly well distributed throughout the year. The actual climatic conditions experienced at any one locale can be quite different from nearby long term climatic stations because of the effects of rugged terrain causing many different micro-climates. Some selected climatic criteria for the two areas are presented in Table 1.

In Appendixes C2 and C3 the mean monthly temperature and precipitation for Prince George and Smithers are presented along with their deviation from the long term normal for each of the test years. The temperature regimes for Smithers and Prince George are very similar. The annual long term temperature for Prince George is higher. Precipitation, and especially its distribution during the growing season, has a direct effect on the production levels of forage and this is reflected in higher forage yields at Prince George than at Smithers under similar conditions.

Table 1. Selected long-term climatic data for Smithers and Prince George.

	Smithers	Prince George
Temperature (°C)		
Mean Annual	3.1	3.3
Mean Maximum	9.3	9.0
Mean Minimum	-3.1	-2.5
Mean May-Sept.	11.6	12.2
Mean Maximum May-Sept.	19.2	19.1
Mean Minimum May-Sept.	3.9	5.2
Precipitation (mm)		
Mean Annual Rainfall	324	400
Mean Annual Snowfall	1669	2334
Mean Annual Total Prec.	492	621
Mean Total Prec. May-Sept.	208	288
Growing Season (days)		
Frost-free days	109	119
No. of degree days	1084	1186

The Test

The test was initiated in 1975 and 1976 at three different sites, each with its own distinct soil type. The two tests at Smithers were located on a Driftwood loam and a Doughty clay. At Prince George the test was on a Pineview clay soil type. The tests at Smithers ran from 1975 to 1979 inclusive, and at Prince George from 1976 to 1980.

Three separate trials were conducted at each site. These were the nitrogen (N) rate, split N application and minus fertilizer trials. The N rate trial had six treatments consisting of 0, 56, 112, 224, and 336 kg N/ha N. The split N trial had N applied either as a single application in the spring or a split equal application between spring and after the first cut. The minus trial tested the effect of not adding a given nutrient (N, P, K, or micronutrients) while all the other nutrients were available in sufficient quantities. This type of trial tests whether or not a given nutrient is deficient in that soil. Nitrogen was applied as urea (46-0-0), phosphorus as triple super phosphate (0-45-0), potassium as potassium chloride (0-0-60), and sulfur was applied as elemental sulfur (0-0-0-99). The micronutrient treatment included a complete macronutrient treatment (NPKS) plus the four minor elements: boron (B), copper (Cu), zinc (Zn), and molybdenum (Mo). The minor elements were applied at 2.24 kg/ha for B, Cu, and Zn and at 1.12 kg/ha for Mo. An outline of the three trials is given in Table 2.

Table 2. Treatments, fertilizer application rates and application schedules for fertilizer trials at Smithers and Prince George.

Treatment No.	N	P	K	S	Spring Applied Fertilizer	Applied After Cut 1
	kg nutrients/hectare*					
			N Rate trial			
1	0	0	0	56	+	-
2	56	0	0	56	+	-
3	112	0	0	56	+	-
4	168	0	0	56	+	-
5	224	0	0	56	+	-
6	336	0	0	56	+	-
			Split N trial			
7	112	0	0	56	112 N	0 N
8	112	0	0	56	56 N	56 N
11	224	0	0	56	224 N	0 N
12	224	0	0	56	112 N	112 N
			Minus trial			
13	224	112	112	56	+	-
14	0	112	112	56	+	-
15	224	0	112	56	+	-
16	224	112	0	56	+	-
18	224	112	112	56**	+	-

* kg/ha * 0.89 = lb/A
**plus minor elements: 1.1 kg/ha of copper, zinc, and boron, and 2.2 kg/ha molybdenum.

The grass-legume mixtures at each of the sites were different. The mixture used at the Doughty clay site was underseeded with barley in 1975 and included red clover (*Trifolium pratense*), timothy (*Phleum pratense*), and some white clover (*Trifolium repens*). The stand consisted of approximately 75% grass). It was found during the first and subsequent harvests that there was an infusion of couch grass (*Agropyron repens*) in the test. The mixture seeded on the Driftwood loam site was Sterling orchardgrass (*Dactylis glomerata*), red clover, some alfalfa (*Medicago sativa*), and some timothy and there was some couch grass evident here as well resulting in a stand consisting of 50% grass. The mixture at this site was seeded in 1974, also with a nurse crop. The Pineview clay site mixture included: Altaswede red clover, timothy, some reed canarygrass (*Phalaris arundinacea*), some birdsfoot trefoil (*Lotus corniculatus*), and alsike (*Trifolium hybridum*). The stand had about

50% grass when established. The seeding rate at each site was approximately 12 kg/ha and barley when underseeded was seeded at about 50 kg/ha.

The fertilizer test treatments were laid out on the grass-legume field in a randomized block design with each block of treatments being replicated four times. The fertilizer treatments were applied by hand on rectangular plots 1.8 x 6 m^2. Spring applications were made before initiation of growth and split applications after each harvest depending on the treatment. Two cuts were taken each year, except 1979, and each trial ran for 4 consecutive years.

Plots were harvested by cutting a 0.6 x 5.4 m^2 strip with a mechanical (Swift Current) flail harvester. Forage weights were recorded. Hand samples were also collected for dry matter determinations and used subsequently for chemical analyses. The hand-clipped samples were dried at 50°C and ground in a Wiley mill to pass through a 1 mm stainless steel screen. The forage weights and dry matter determinations were used to calculate dry matter yield (DMY). Selected samples were analyzed for crude protein (CP) by macro-Kjeldahl, and dry matter digestibility (DMD) by nylon bag method (Lowery et al. 1968 as cited by van Adrichem and Tingle 1975). The DMY and determination of CP and DMD were used to calculate crude protein yield (CPY) and dry matter digestible yield (DMDY).

Soil samples were collected from the minus trial plots during the fall of each year of harvest. Soil samples were air-dried, sieved to 2 mm, and analyzed by the B.C. Ministry of Agriculture and Fisheries soils laboratory in Kelowna. The soil analysis method used to determine nitrate-N was 0.02 N $CuSO_4$ and 0.007 N $AgSO_4$ at a soil to solution ratio of 1:10 and extraction time of 10 minutes (McKeague 1978). The P and K analyses were done by the Bray P-1 and neutral 1 N NH_4OAc (McKeague 1978) methods, respectively.

Analysis of variance was performed on the 5 variables DMY, DMD, DMDY, CP, and CPY, using a repeated measures model with treatments as main plots, cuts as subplots, and years as subsubplots. This was accomplished with the GLM procedure of the SAS software package (SAS Institute Inc. 1985). In the minus trial, the treatment means were further tested using the Duncans Multiple Range test at the 0.05 level of probability.

RESULTS AND DISCUSSION

The response of grass-legume forage mixtures is dependent on both the weather during the growing season and the applied fertilizer. The weather varies from year to year and by the use of fertilizer the available moisture is used most efficiently. Weather data for the two Smithers sites were derived from the Smithers Airport climatic station while at Prince George the Prince George Airport climatic data were used to determine interdependence with forage yield. Since the weather data were not collected at the site, slight differences from the long term climatic

station would occur, especially at Smithers where distances were greater. The climatic data used for interpretation were mean monthly temperature, monthly precipitation and their deviation from the long term mean.

A comparison of selected long term climatic data for Smithers and Prince George is given in Table 1. The mean temperatures are slightly higher for the Prince George site. The range in temperatures at Smithers is greater as the mean maximum temperatures are higher and the mean minimum temperatures are lower than those at Prince George. The mean minimum temperatures during the growing season (May to September) are 1.3°C lower at Smithers, with an average of 3.9 and 5.2°C at Smithers and Prince George, respectively. Hence, the chance of frost at Smithers is considerably greater. The long term average days of frost for Smithers are 13, 5, 1, 2 and 10 for May, June, July, August and September, respectively. The average days for frost at Prince George for the same period are 10, 2, 0, 1 and 8 (Broersma and Tingle, 1988). While the average number of frost-free days at Prince George is 119, Smithers has 109. There are, on average, 100 more growing degree days at Prince George than at Smithers. The precipitation at Prince George is considerably higher. Mean annual rainfall, mean annual snowfall, mean annual total precipitation and May to September precipitation exceed Smithers by about 75, 675, 125 and 75 mm, respectively. These climatic conditions indicate a slightly better environment for growing crops at Prince George.

Smithers Climatic data

Climatic data for the Smithers Airport are given in Appendix B1 and Figures 1 and 3. The mean monthly temperature for May for each of the years 1976 to 1979, inclusive, was below the long term average of 9.2°C, while temperatures in April were all above the normal. Temperatures during the 1976 growing season were below the long term normal except for September. The mean monthly temperatures for the years of 1977 and 1978 were close to normal with the temperatures being well above normal for the months of August in 1977 and July in 1978. In 1979, May and June were cooler, while July to September were well above the mean monthly temperatures for those months. The total precipitation probably has the greatest effect on the total yield as none of the test sites are irrigated. Nitrogen and water are the most limiting requirements for crop growth once the temperature is adequate for growth. All years had two harvests except for 1979. In June of 1979, 17.3 mm less than normal total precipitation fell resulting in a water deficit that was continued into July and August with 3.1 and 6.6 mm less precipitation falling than the long term normal. There was inadequate precipitation for a second cut. In 1978 the months of May, June and July had lower than normal amounts of precipitation with 5, 15.3 and 28.9 mm, respectively. In August much higher rainfall than normal occurred. These precipitation distributions resulted in a single cut being harvested in 1979 and a very small second cut in 1978. Precipitation distributions were normal or higher than normal for 1976 and 1977 and adequate second cuts were harvested.

Prince George Climatic Data

Prince George climatic data are given in Appendix B2 and Figures 2 and 4. The mean monthly temperatures for May and June for the years 1977 to 1979 inclusive were slightly below or very close to the long term normal. Temperatures in 1979 for July to October inclusive were above normal by 1.1 to 2.4°C. Mean temperatures for the other months and years fluctuated above and below normal with no consistent pattern. The lowest amounts of summer precipitation were in 1978 and 1979. In 1979 precipitation was consistently below the normal for the months July to November resulting in only one cut being harvested. The precipitation pattern during 1978 was similar with June also having lower than normal precipitation. Yields of second cuts appear to relate closely to available moisture.

Nitrogen Rate Trial

Dry matter yield for the nitrogen rate trial at 3 sites, 6 Nitrogen rates (0, 56, 112, 168, 224, and 336 kg N/ha), 2 cuts per year for 4 years are given in Appendix C1 and graphed in Figures 5a and 5b. The four-year average of cut 1 DMY of the unfertilized plots ranged from 2.71 t/ha on the Doughty clay to 4.50 t/ha on the Pineview clay. These differences are due to climate, soils and forages species. The two Smithers sites, Driftwood loam and Doughty clay, both had lower yields than the Prince George Pineview clay. The 4 year averages for climatic data show that Prince George receives a much higher precipitation during the year and the growing season than Smithers.

There were significant first cut yield responses to N fertilizer as shown in Figure 5a. Maximum DMY for the first cut was about 3.7, 4.4, and 7.2 t/ha for the Doughty clay, Driftwood loam and Pineview clay sites, respectively. The yield curve starts to level off at the 168 kg N/ha rate at all sites. The analysis of variance indicated that the effect of fertilizer rate was statistically significant at the 0.01 level for DMY at all three sites.

Second cut yields also showed responses to single applications of N fertilizer in the spring (Figure 5b). During the years 1976, 1977, and 1978, the second cut yields were about one-third to two-thirds of the first cut. Average unfertilized plot yields for second cut were 1.31, 2.14, and 1.66 t/ha for the Doughty clay, Driftwood loam, and Pineview clay sites, respectively. Maximum average yields for the second cut were 2.54, 3.00, and 3.23 t/ha. In contrast to first cut yields, there was no leveling off of yields, even at the high rate of 336 kg/ha N. This is probably because the N rates were applied 4 to 5 months earlier and much of it had been lost to uptake by the first crop, to soil organisms, leaching and volatilizition.

Dry matter digestibility data measured _in vivo_ by the nylon bag method are given in Appendix C2 and graphed in Figures 6a and 6b for all three sites. Increasing N fertilization appeared to decrease DMD. This effect

Figure 1. Temperature data for Smithers.

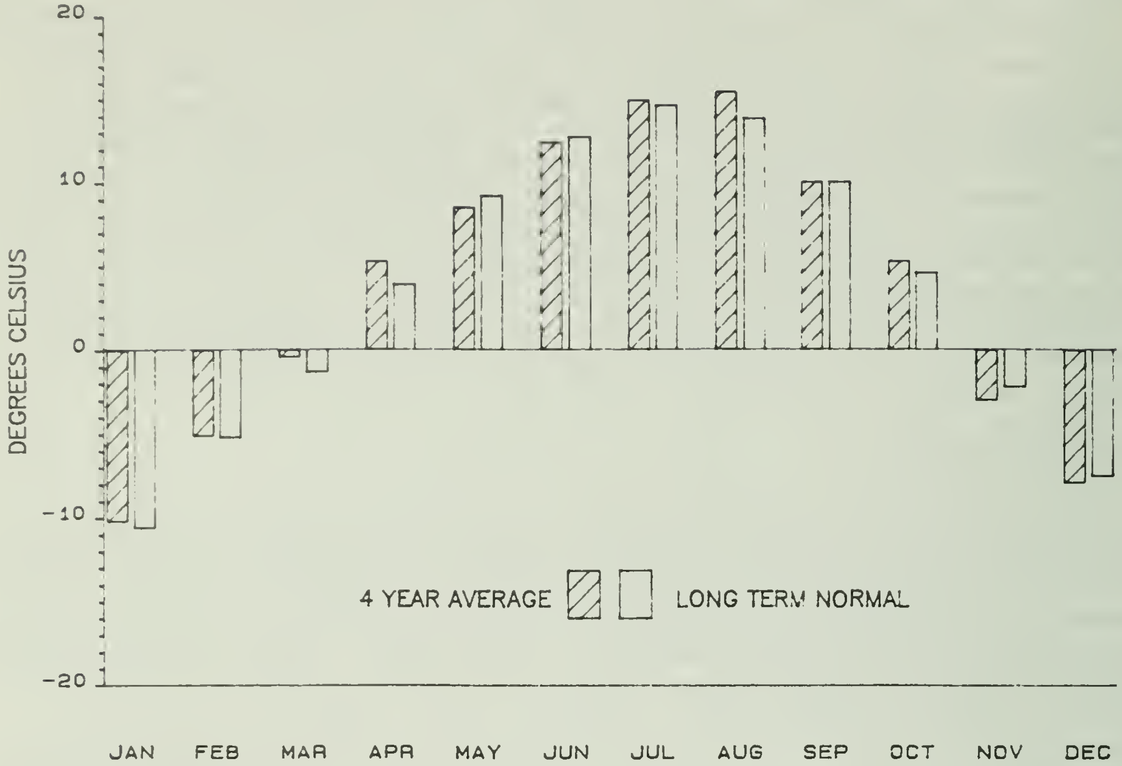


Figure 2. Temperature data for Prince George.

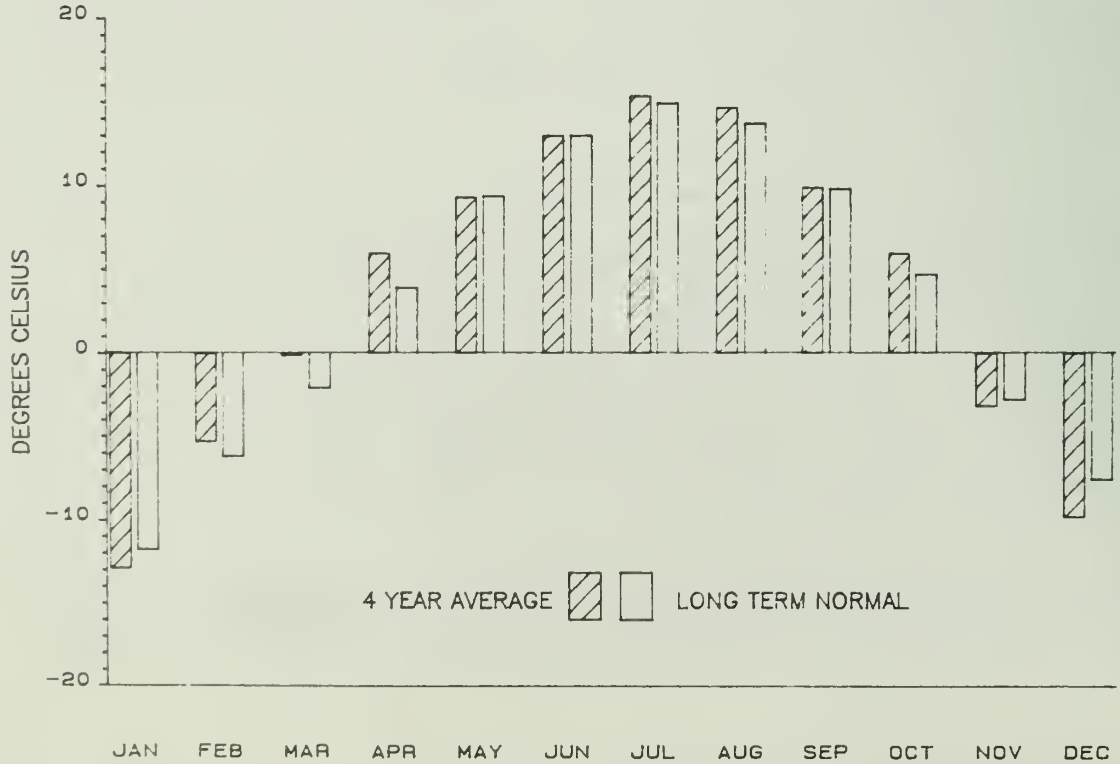


Figure 3. Precipitation data for Smithers.

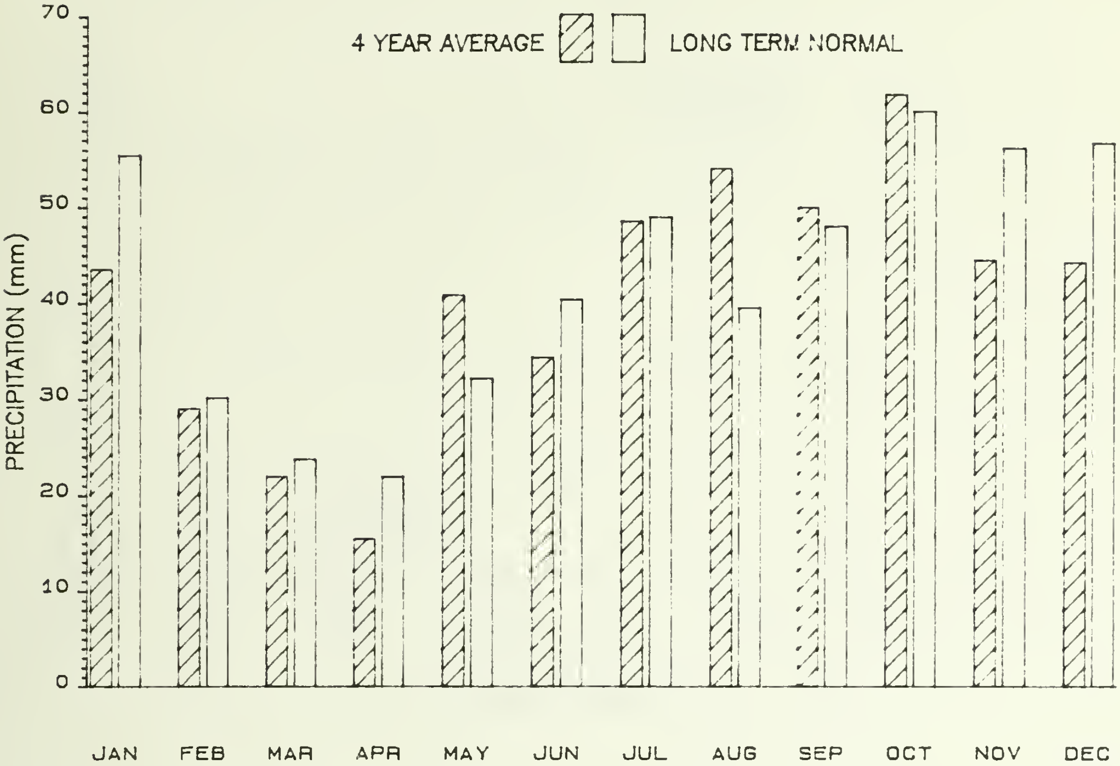


Figure 4. Precipitation data for Prince George.

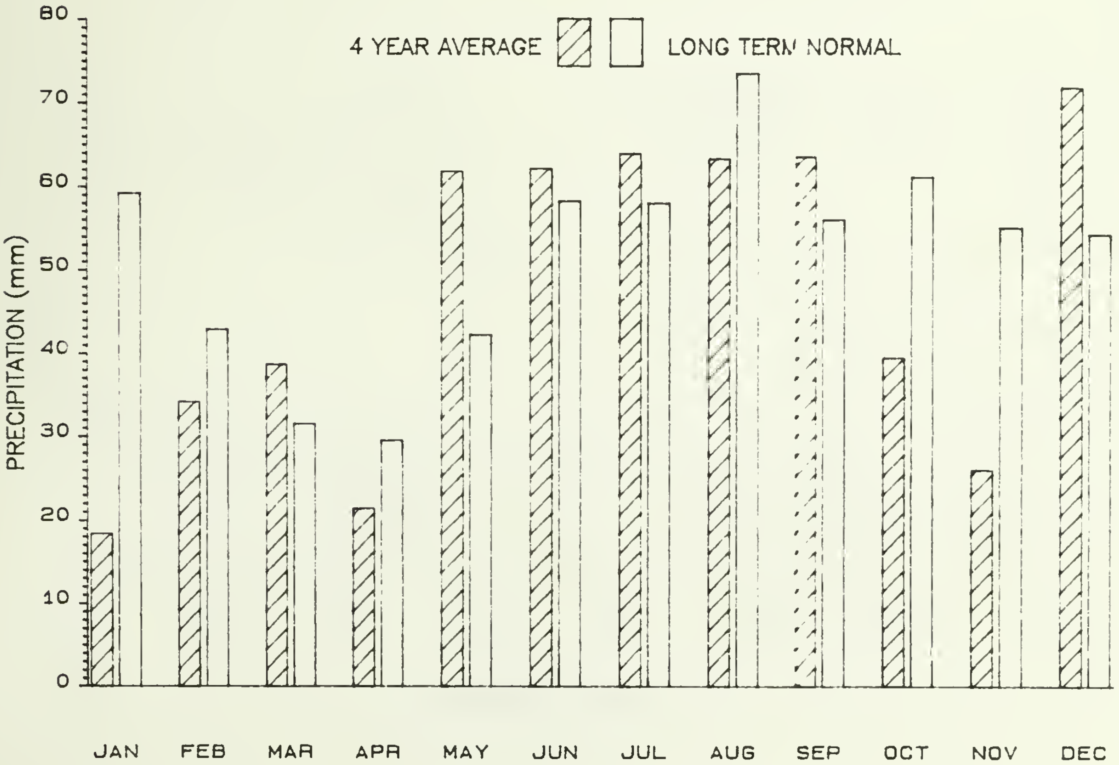


Figure 5a. Cut 1 DMY for N rate trial.

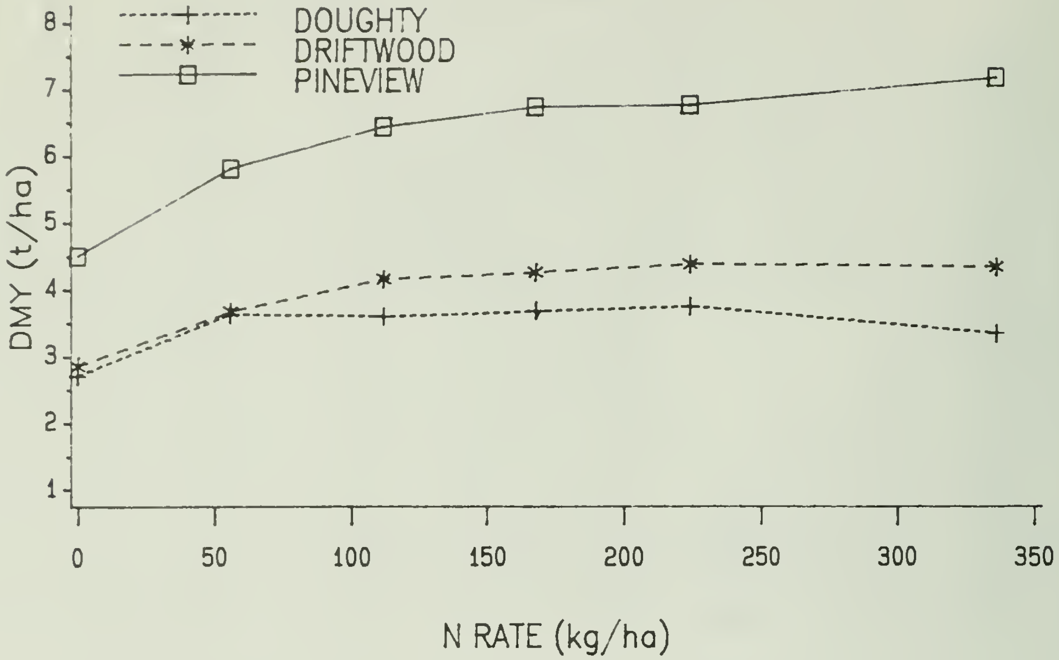


Figure 5b. Cut 2 DMY for N rate trial.

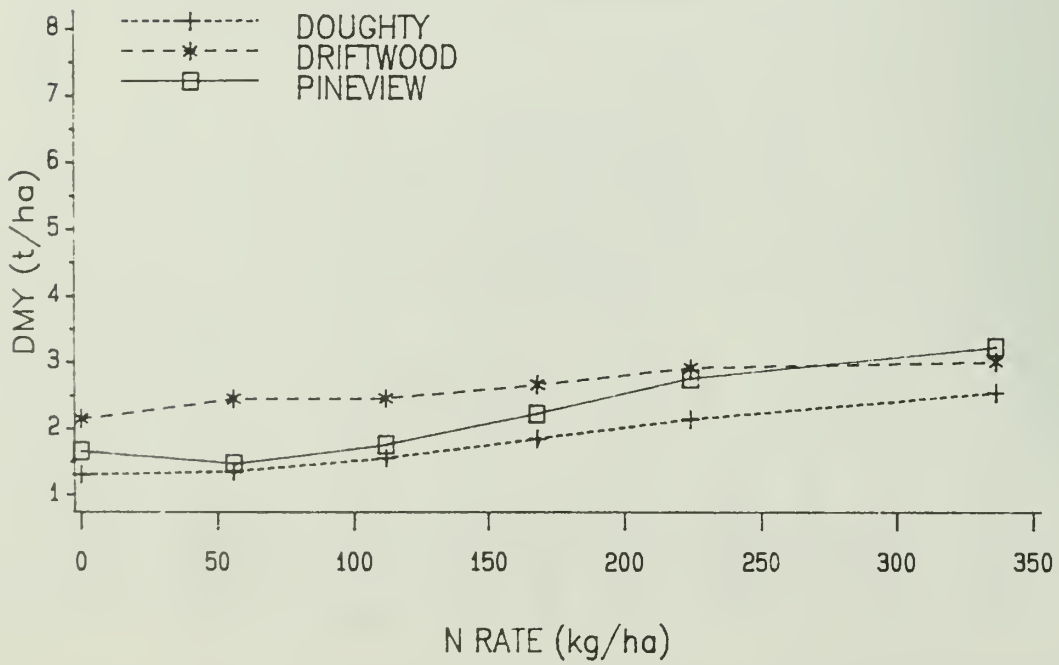


Figure 6a. Cut 1 DMD for N rate trial.

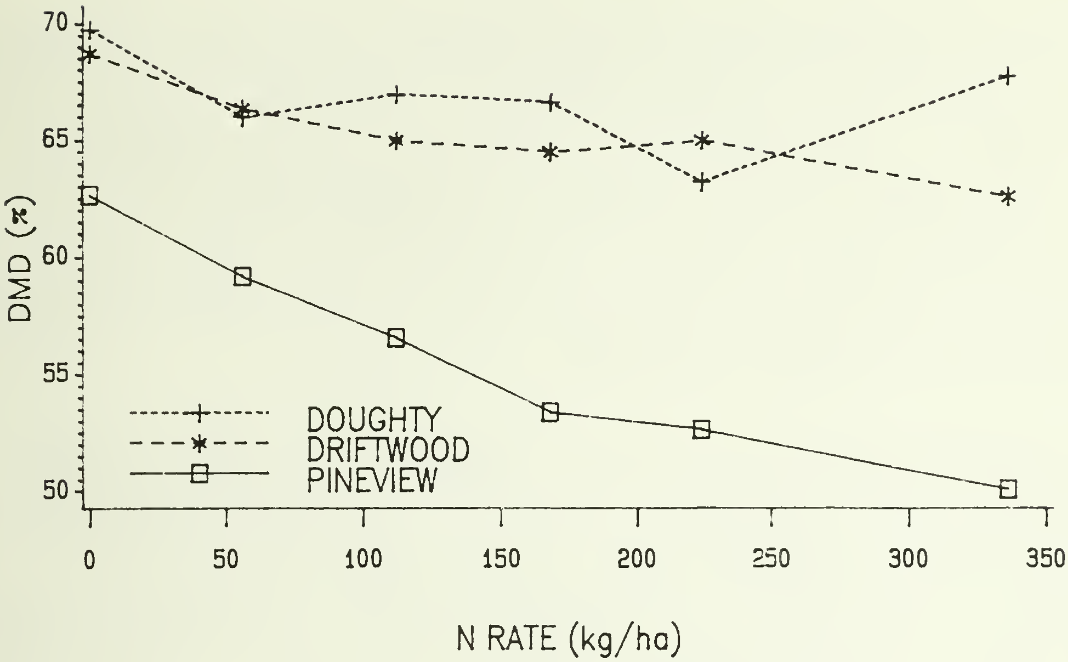
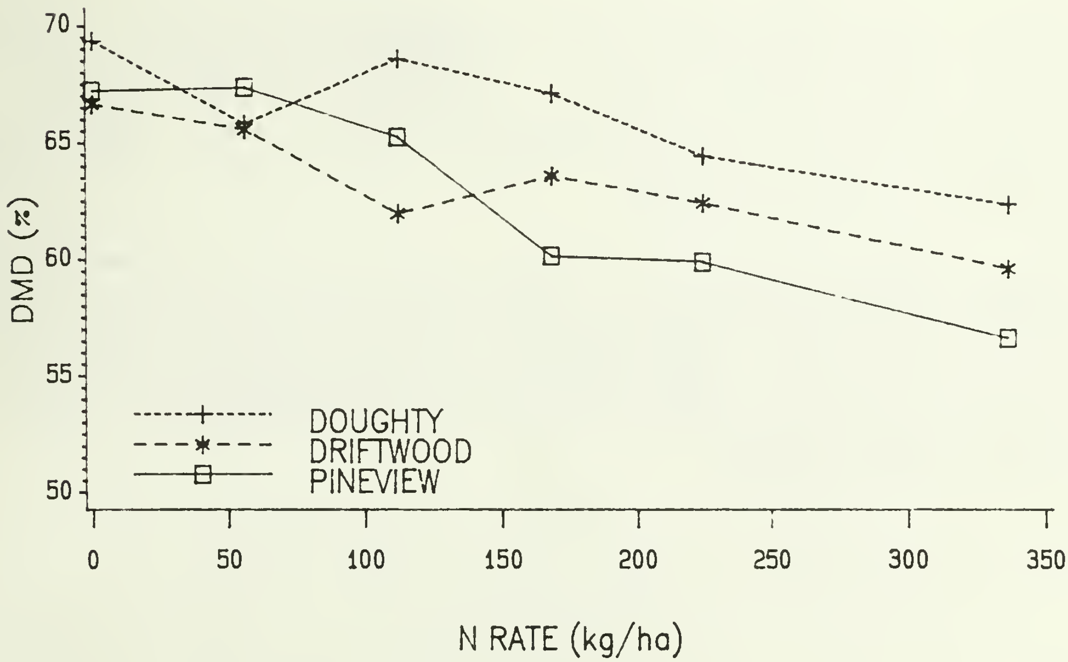


Figure 6b. Cut 2 DMD for N rate trial.



was probably due to a decrease in legumes from N fertilization, as grasses are stimulated more by high rates of N fertilizers than legumes.

Average DMD ranged from 62.6 to 69.8% for unfertilized treatments and from 50.1 to 68.6% for the fertilized treatments. There was no consistant pattern for DMD for first versus second cut. Dry matter digestible yield data for three sites are given in Appendix C3 and graphed in Figure 7a and 7b. Dry matter digestible yield is calculated by the multiplication of DMY by DMD. Dry matter digestible yield shows significant increases due to N fertilization. Figure 7a shows first cut DMDY for all three sites. It is noted that DMDY increases with increasing N to a maximum at the 168 and 224 kg/ha N rates and then decreases at the highest rate. For the second cut, there was an increasing linear relationship between N rate and DMDY with no leveling off (Figure 7b). As with second cut DMY, this was probably due to N losses since spring fertilization.

Crude protein data is given in Appendix C4 and graphed in Figures 8a and 8b for all three sites. First cut average CP for the unfertilized plots ranged from 11.8 to 12.7%. The effect of N fertilizer on first cut CP varied depending on the site and N rate. At the Doughty clay site, a low N rate of 56 kg/ha N decreased CP slightly while higher rates increased CP significantly. At the Driftwood loam site increasing N fertilizer increased the CP to a maximum of 16.1%. At the Pineview site, the 56 and 112 kg/ha decreased CP from 12.7% to about 11%. The high rates again increased CP to a maximum of 13.4%.

This is probably due to a "dilution effect" where lower N rates increase DMY production more than crude protein. At high rates, DMY increases level off and surplus N can be used for crude protein production. This effect is probably also accentuated by a decrease in legumes with N fertilization.

Crude protein tended to be higher for the second cut forage compared to the first cut on the Doughty clay and Pineview clay but lower for the second cut for the Driftwood loam site. This is in part due to species differences at the Driftwood loam site. The above cut effects for all three sites were statistically significant at the 0.01 level. Higher CP in second cut forage is related to a dilution effect and also because less mature forage is being harvested.

Crude protein yield data for the three sites is given in Appendix C5 and graphed in Figures 9a and 9b. Crude protein yield was calculated from the multiplication of DMY by CP%. Figure 9a shows a graph of first cut CPY for all three sites. Crude protein yield increases with increasing N fertilization and shows a slight leveling off at higher N rates. Second cut CPY did not increase significantly from spring fertilization except at the highest N rate ($P \leq 0.01$).

Figure 7a. Cut 1 DMDY for N rate trial.

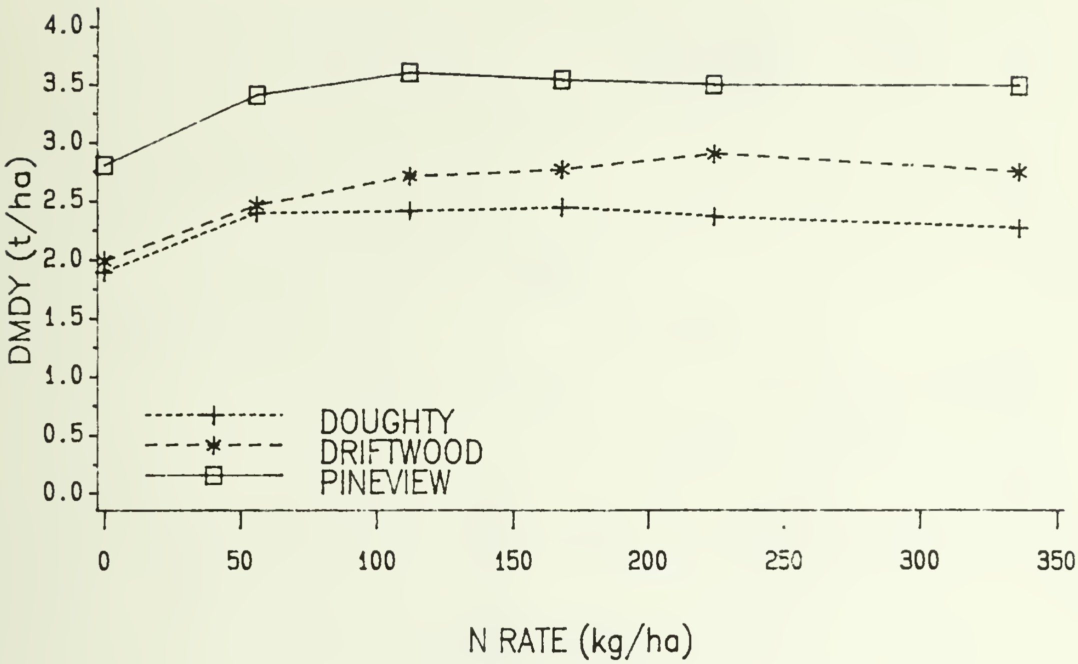


Figure 7b. Cut 2 DMDY for N rate trial.

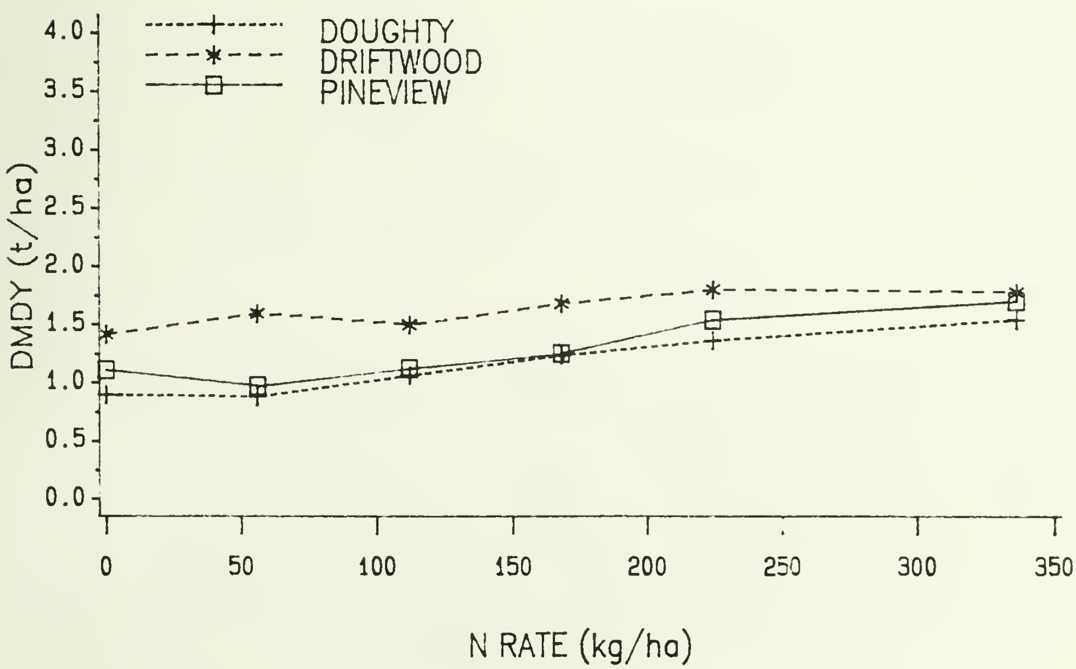


Figure 8a. Cut 1 CP for N rate trial.

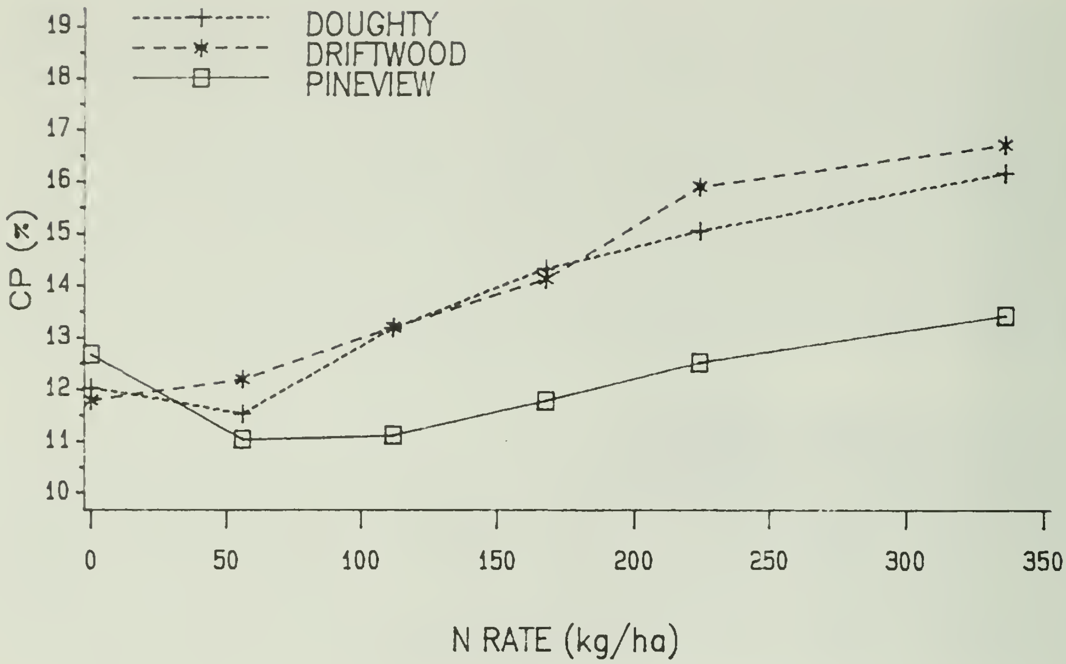


Figure 8b. Cut 2 CP for N rate trial.

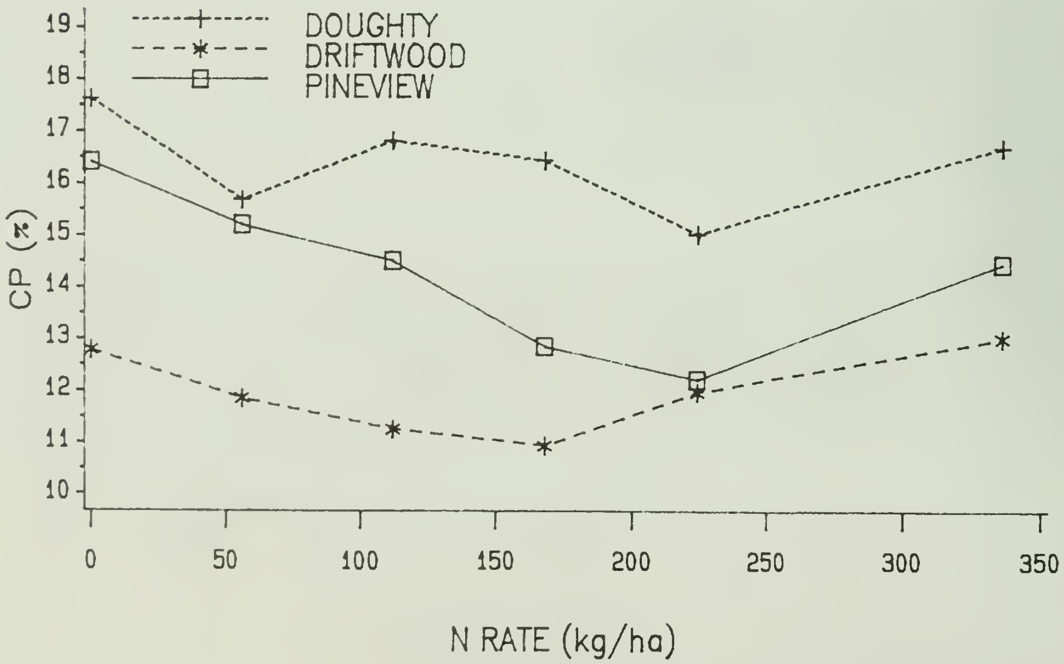


Figure 9a. Cut 1 CPY for N rate trial.

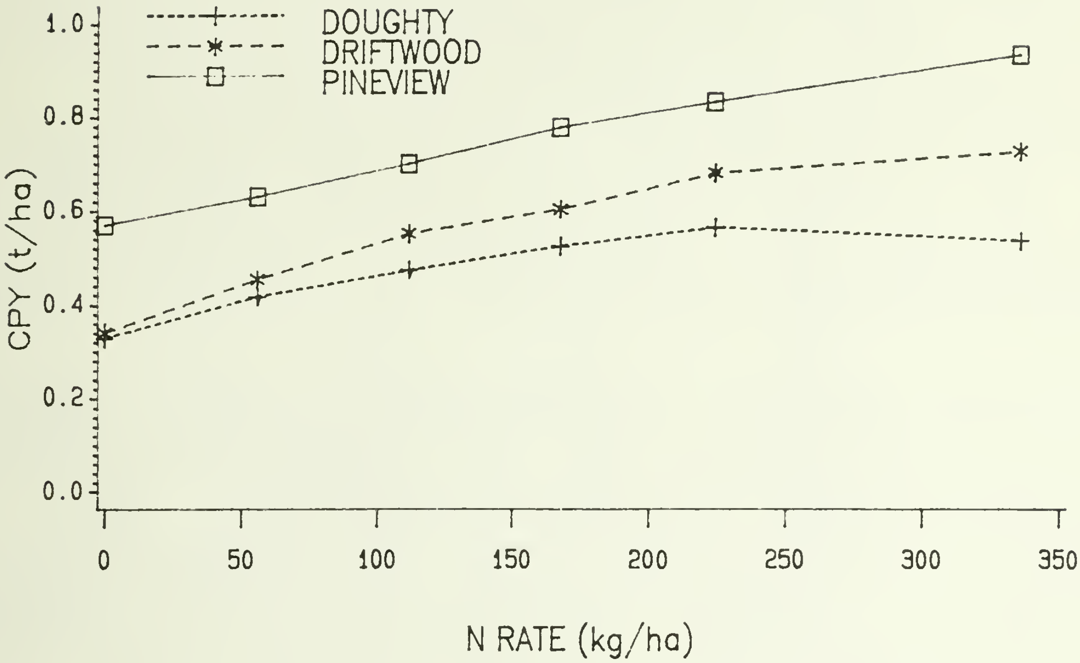
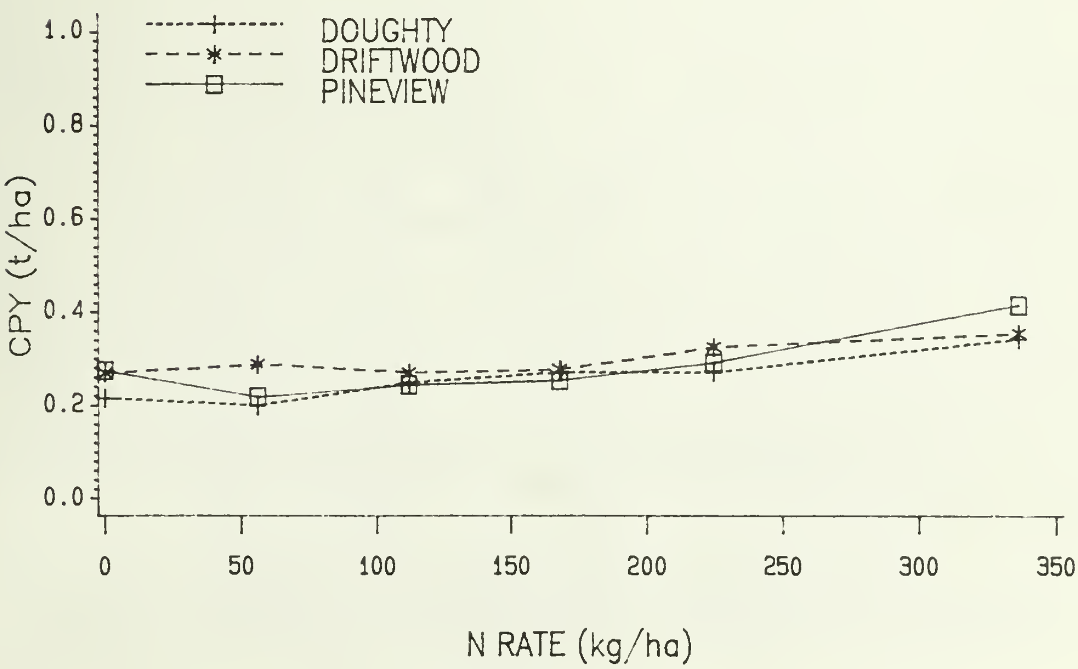


Figure 9b. Cut 2 CPY for N rate trial.



Split Nitrogen Trial

This trial compared two rates of nitrogen applied either as a single application in the spring, or split equally between spring and after the first cut. Average total DMY was usually higher for split application versus single application but the differences were only in the order of 2 to 5% (Figures 10a and 10b, Appendix C6). Also, splitting the N applications shifted some yield from first to second cut. The split application tended to lower DMD a little (Figures 11a, 11b and Appendix C7). This is related to the effect of N rate on DMD. With a single application of N, first cut DMD was lower but second cut DMD was higher, more than making up for the first cut. Effects of single and split applications were less noticable with DMDY, with no significant difference between the two (Appendix C8).

The low N rate depressed CP content compared to either the high N rate or zero N rate (Figure 8a). The split applications resulted in lower CP (Figures 12a, 12b, and Appendix C9). This is probably due to the dilution effect of lower N rates on CP content mentioned earlier. The split applications resulted in two applications of lower N rates. Water deficits during the growth of the second cut resulted in less efficient fertilizer use. The CPY was higher for the first cut with the single application as it received all the fertilizer prior to that cut (Appendix C10). The CPY for the second cut was always higher for the split application and this was much more pronounced at the 224 than 112 kg N/ha rate. When the first and second cuts were totalled the CPY was nearly the same for both cuts.

Minus Trial

The five treatments in the minus trial consisted of a complete which included N, P, K and S, a complete without N (-N), a complete without P (-P), a complete without K (-K), and a complete plus micronutrients (Table 2). Dry matter yield data for all three sites are given in Figure 13 and Appendix C11. As expected DMY was highest for the complete and complete plus micronutrient treatments. There was no significant difference in yields between these two treatments indicating no response to the added micro-nutrients. The -N treatments consistently yielded the lowest, averaging from 67% to 74% of maximum yield. This indicated that N was the most limiting nutrient. The second most limiting nutrient was P. All sites showed some deficiency in P, with the -P treatments yielding from 78% to 94% of maximum. The Doughty site was the most P deficient with a DMY of 78% compared to the complete. These treatments were significantly different from the complete on all three sites according to the Duncan's multiple range test. The -K treatments were not significantly different from the complete for all sites. K was not deficient for DMY on these soils, although K fertilization may have other effects on the forage stand such as winter hardiness and longevity of forage crops and especially the legume component.

The soil analysis data for the minus trial is given in Tables 3 to 5. Soil nitrate-N levels showed a slight tendency to be higher on the

Figure 10a. DMY for split N trial at 112 kg N/ha.

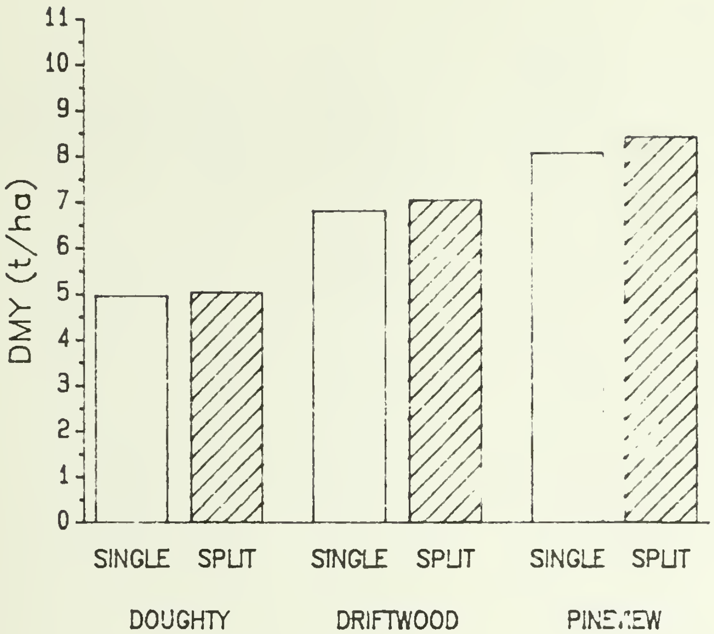


Figure 10b. DMY for split N trial at 224 kg N/ha.

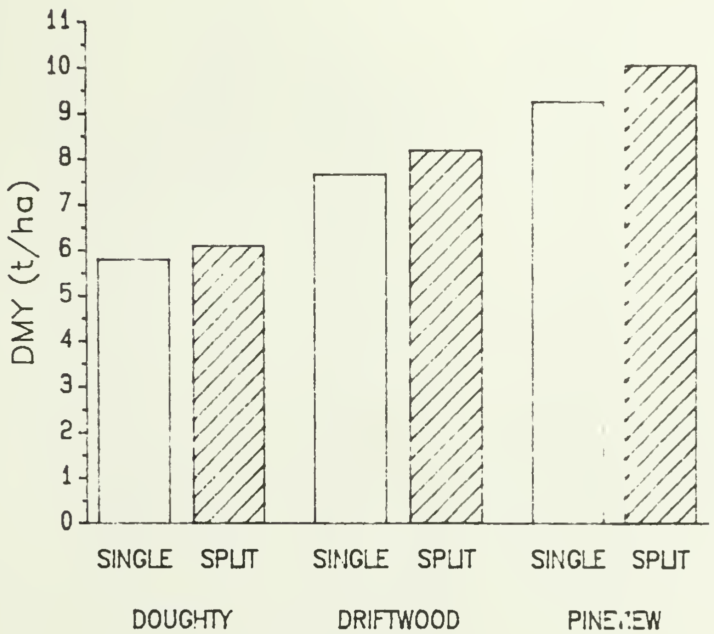


Figure 11a. DMD for split N trial at 112 kg N/ha.

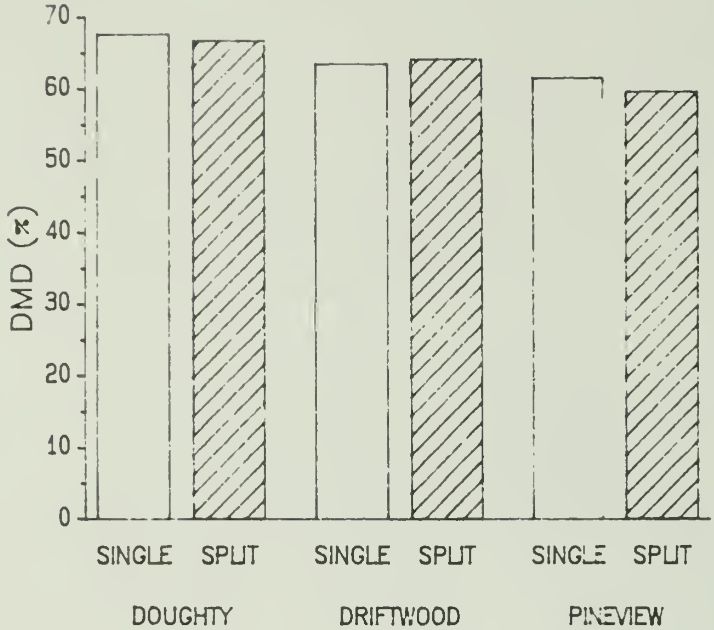


Figure 11b. DMD for split N trial at 224 kg N/ha.

Figure 12a. CP for split N trial at 112 kg N/ha.

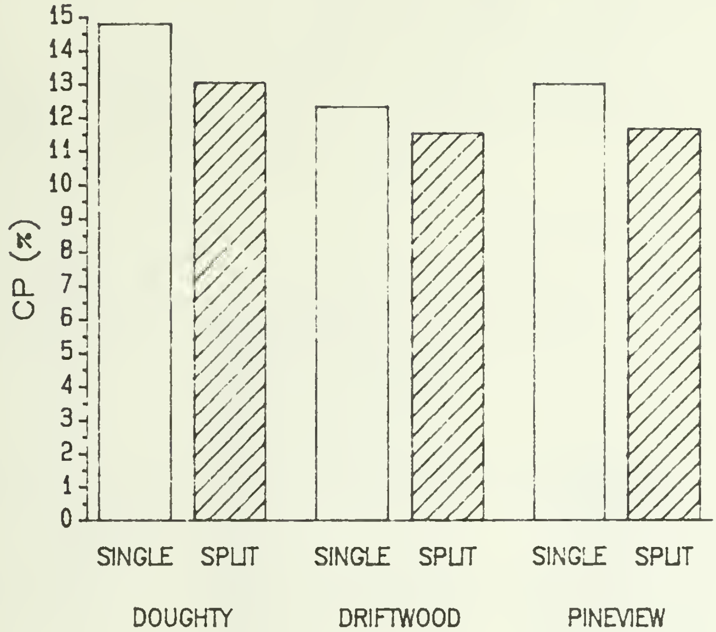


Figure 12b. CP for split N trial at 224 kg N/ha.

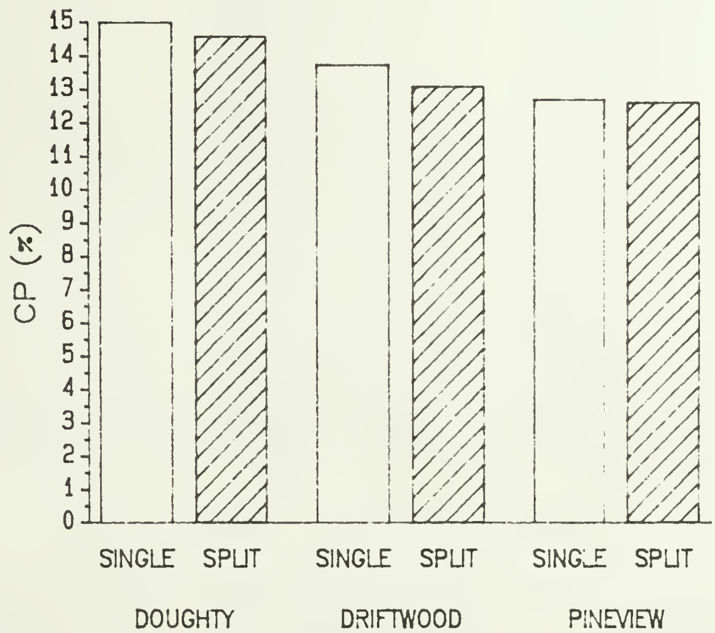
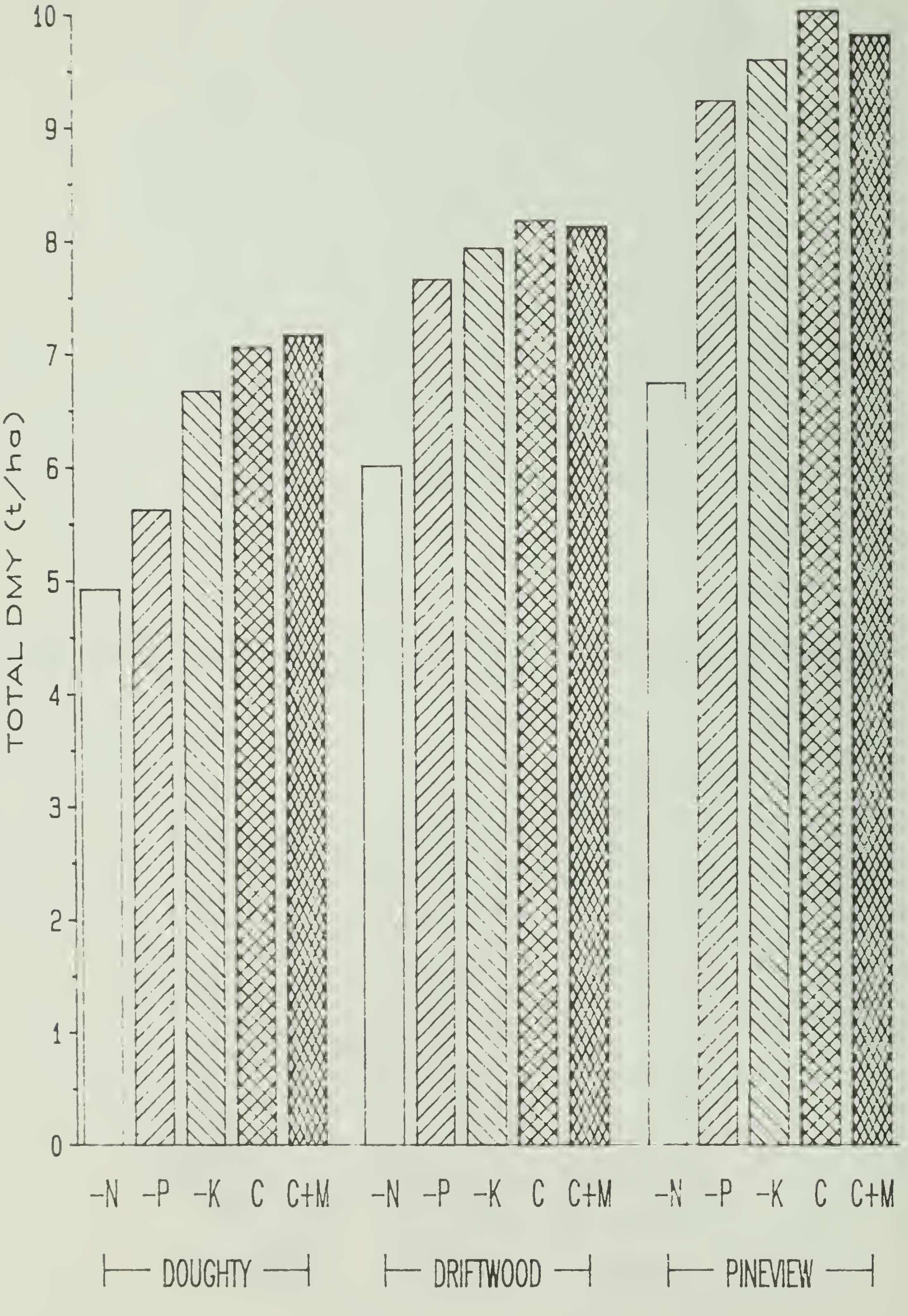


Figure 13. Cut 1 and 2 DMY for minus trial.



fertilized plots but the averages were always less than 8 mg/kg regardless of treatment. These levels fall in the low range for nitrate-N (Table 6). This shows that by the fall of each year little or no free nitrate-N was left in the soil from fertilizer, even at a high rate of 224 kg N/ha. It was all taken up by the plant, soil micro-organisms or lost from the soil system. There was also no accumulation of nitrate-N in the soil over the four years of each trial. This is not to say that soil nitrogen reserves remained the same in the fertilized versus unfertilized treatments. It is probable that N stored in the organic components of the soil increased in the fertilized plots.

The soil P data is given in Table 4. Soil P tended to decline on the unfertilized treatments and increase on the fertilized treatments. The P fertilized treatments consistently showed higher soil P levels than the unfertilized treatments. This showed that there is a carry over from year to year of fertilizer P applied at a rate of 112 kg/ha. It is also

Table 3. Soil nitrate nitrogen data for minus trial.

Site	Treatment kg N/ha	Year 1	Year 2 (mg/kg N)	Year 3	Year 4
Doughty	0	1	2	1	4
	224	1	3	1	7
Driftwood	0	2	1	1	2
	224	1	4	1	4
Pineview	0	1	1	4	1
	224	5	1	4	1

Table 4. Soil phosphorus data for the minus trial.

Site	Treatment kg P/ha	Year 1	Year 2	Year 3 (mg/kg P)	Year 4
Doughty	0	9	9	9	9
	112	15	15	25	21
Driftwood	0	11	11	9	9
	112	10	11	19	25
Pineview	0	27	26	23	18
	112	29	32	31	60

interesting to note that the Doughty clay site, which rated deficient in P on (Table 6) the unfertilized treatment, gave the most response to P fertilizer.

The soil K data is given in Table 5. There were no consistent trends in the K levels on the fertilized versus unfertilized treatments. General experience has shown that K soil analysis is much less reliable for predicting fertilizer response compared to P soil analysis and that the natural soil levels are at present adequate. Soils with potassium deficiencies generally tend to be coarse textured soils (sandy soils) or organic soils.

The DMD for the minus trial varied with treatment (Appendix C12). There were no significant differences between the complete, complete plus micronutrients and -K treatments. The only difference observed was that the Pineview soil produced forage with the lowest DMD (Figure 14). The -N always resulted in a higher DMD than the complete treatment. A similar observation was noted for the -P treatment on the Doughty soil--the only one that was deficient in P and had the greatest response to applied fertilizer P. The calculated DMDY (Appendix C13) was greatest for the complete, complete plus micro-nutrients and -K treatments as all nutrients were sufficient. If any nutrient element is deficient then the DMDY is also decreased significantly.

The %CP data is presented in Figure 15 and Appendix C14. Differences in the percent CP were not that different among treatments in the minus trial. The percent CP for the second cut was significantly greater than it was for the N rate and split trials. The CPY trends (Appendix C15) were very similar to that observed for the DMDY.

Table 5. Soil potassium data for the minus trial.

Site	Treatment kg K/ha	Year 1	Year 2	Year 3	Year 4
			(mg/kg K)		
Doughty	0	90	67	71	74
	112	91	97	91	76
Driftwood	0	75	74	65	64
	112	61	54	59	60
Pineview	0	145	136	128	167
	112	173	162	182	180

The Economics of Fertilizer Application

The costs of applying fertilizer are significant and include fertilizer, equipment and labour. The greatest returns in dollars or crop

Figure 14. Cut 1 and 2 DMD for minus trial.

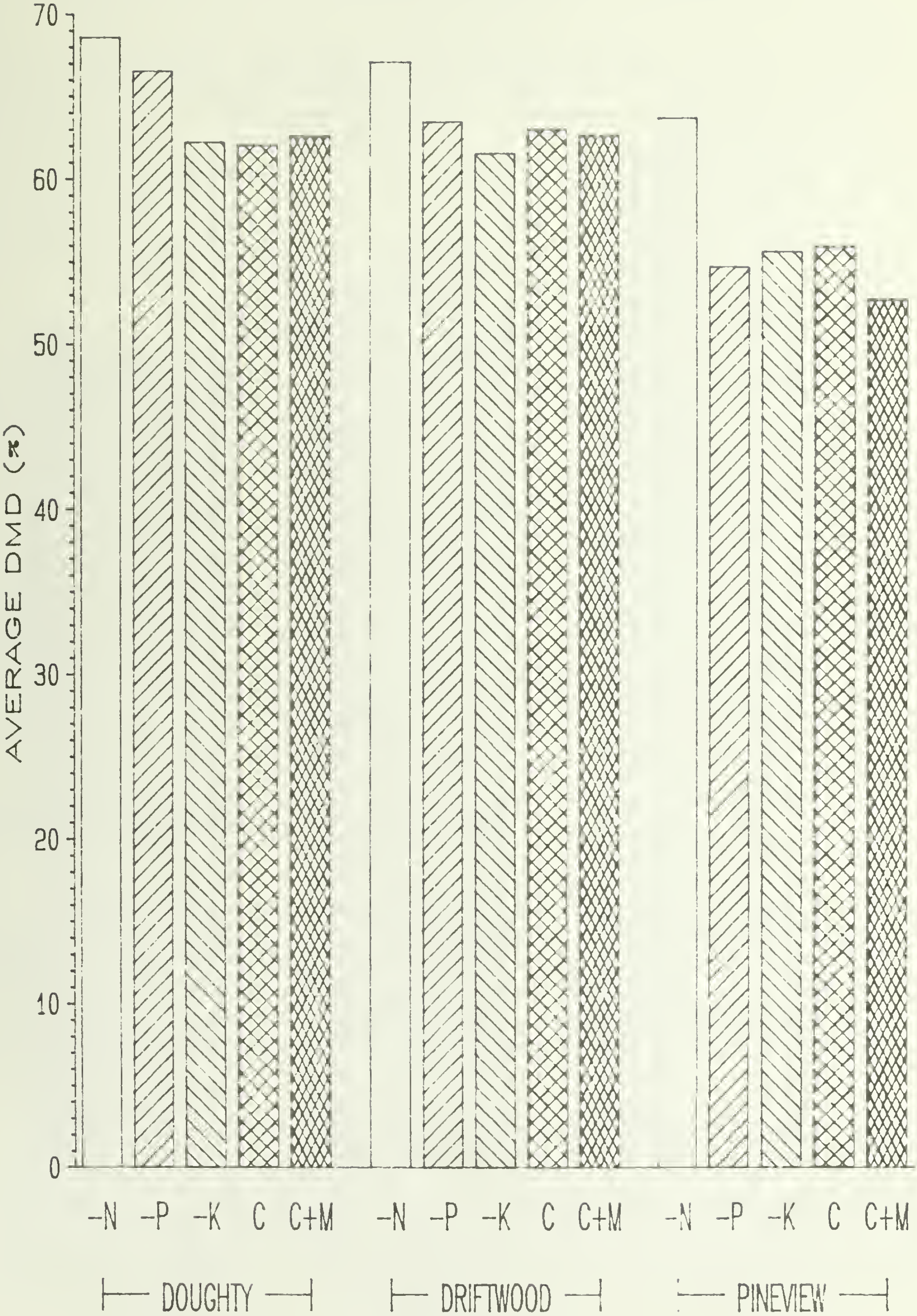
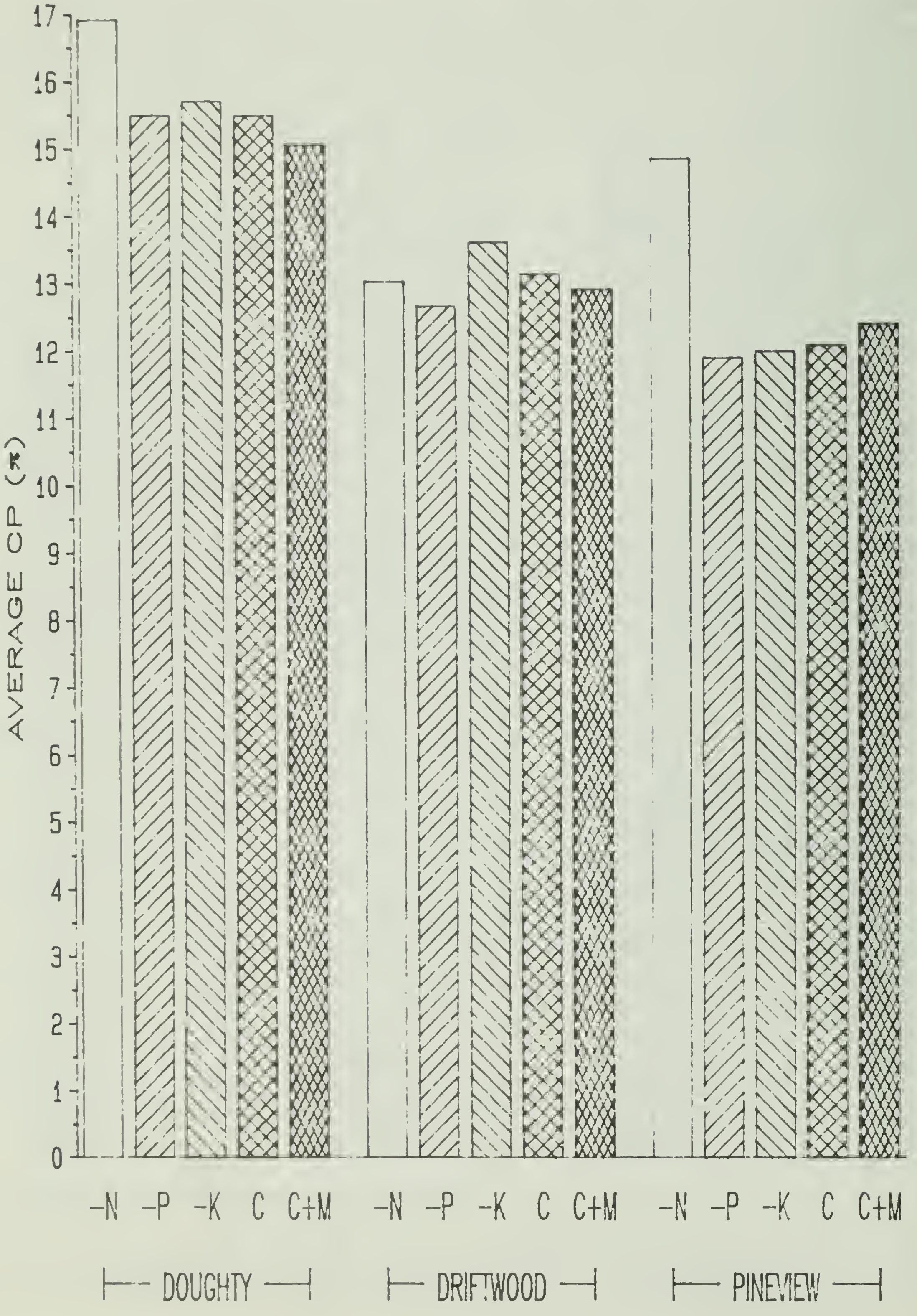


Figure 15. Cut 1 and 2 CP for minus trial.



is expected from the application of nutrients that are deficient. In the Central Interior of B.C. that nutrient is mainly N. If, in addition to N, other nutrients such as P or S are limiting the expected yield increases can be depressed if only N is applied. The deficiency of the other nutrient(s) has to be corrected to realize the full benefits.

Table 6. Soil test interpretations for the Central Interior.

Nutrient	Soil test values (mg/kg)	Rating
Nitrogen	0 - 7	L-
	8 - 10	L
	11 - 25	M
	26 - 40	H
	41+	H+
Phosphorus	0 - 5	L-
	6 - 10	L
	11 - 15	L+
	16 - 20	M-
	21 - 25	M
	26 - 35	M+
	36 - 70	H
	70+	H+
Potassium	0 - 50	L
	51 - 75	L+
	76 - 100	M-
	101 - 125	M
	126 - 175	H
	175+	H+

Note: Taken from Table 9 of Neufeld 1980.

The application of N fertilizer at 56 or 112 kg N/ha resulted in an average increase of 1.1 and 1.6 tonnes/ha at all three study sites, (Table 7). The 56 kg N/ha rate resulted in a yield increase of about 1 tonne per hectare at each location. The addition of a further 56 kg N/ha for a total 112 kg N/ha gave a further increase of 0.16, 0.48 and 0.91 tonnes/ha for the Doughty, Driftwood and Pineview soils, respectively.

The cost of applying fertilizer was assumed to be the same at each location. The price of the nitrogen was calculated using Urea fertilizer at $322/tonne, or $0.70/kg of N. The cost of the fertilizer applied is calculated by multiplying the number of kilograms of N applied per hectare times $0.70, which works out to $39.20 and $78.40 for 56 and 112 kg N/ha, respectively (Table 8). The application costs are much more difficult to

determine and vary from producer to producer and from area to area because of the different input costs. The application costs take into consideration operating and overhead costs, including fuel and repairs, labour and depreciation. Values for these costs were obtained from the B.C. Ministry of Agriculture and Fisheries (Roger Keays, personal communication, June 2, 1988) for two areas in the B.C. Interior, Kamloops and Williams Lake. The highest operating, labour and depreciation values from the two areas were used in estimating the cost for the Central Interior in order to avoid underestimation. The costs per hectare for operating, labour and depreciation amounted to \$3.29, \$5.23 and \$6.10, respectively, for a total of \$14.63 per hectare (Table 8). The value of the hay crop was set at \$82.50 per tonne so that a net return could be calculated. Returns of between \$26.21 and \$38.58 can be expected for applications of N at 56 kg/ha. For applications of 112 kg N/ha, the returns per hectare were greatest at Prince George with \$72.81 per hectare because of the large response to applied N fertilizer. On the Driftwood soil, the returns were also good at the higher application rate at nearly \$39 per hectare. On the Doughty soil there was no financial benefit at

Table 7. Expected returns in tonnes per hectare to applied nitrogen fertilizer at three sites in the Central Interior of B.C.

Site	Applied N Fertilizer (kg N/ha) 0	56	112	Yield increase over check 56	112
			t/ha		
Doughty	4.02	4.99	5.15	0.97	1.13
Driftwood	5.00	6.12	6.60	1.12	1.60
Pineview	6.17	7.27	8.18	1.10	2.01
Mean				1.06	1.58

Table 8. Expected economic returns to applied nitrogen fertilizer in \$ per hectare at three sites in the Central Interior of B.C.

Site	Fertilizer Costs (kg N/ha) 56	112	Application Costs	Expected Returns	
			\$/ha		
Doughty	39.20	78.40	14.62	26.21	0.21
Driftwood	39.20	78.40	14.62	38.58	38.98
Pineview	39.20	78.40	14.62	36.93	72.81
Mean				33.91	37.33

the higher fertilizer rate as the returns equalled the input costs. Approximately 0.6 tonnes of DMY are required to offset the cost of 50 kg N per hectare.

CONCLUSIONS

The N rate trial showed definite responses to N fertilizer, with maximum DMY increases of 123 to 194% over the 0 kg N/ha rate. Yield increases occurred up to rates of about 168 kg N/ha after which they leveled off. N fertilization also tended to lower DMD. Crude protein was either unaffected or decreased at low N rates (56 to 112 kg N/ha)and then increased at higher N rates. This negative effect of N fertilizer on grass-legume forage quality is contrary to the commonly held belief that application of N fertilizer at any level will increase crude protein value of all forages.

The split nitrogen trial showed slight increases in total DMY for split applications versus single applications but the increases were quite small, in the order of 2 to 5%. These small increases in yield do not warrant the splitting of nitrogen applications under Central Interior climatic conditions.

The minus trial showed that N is by far the most limiting nutrient for forage crop production. Phosphorus was also limiting but to a lesser degree. Dry matter yields for the Doughty, Driftwood and Pineview sites were 78, 93 and 92% of maximum if only P was limiting. Potassium and the micronutrients tested were not deficient.

In terms of returns on fertilizer inputs, fertilizing with N at about 50 kg/ha in the spring appears to be the most cost effective. At fertilizer rates of 56 kg N/ha dry matter yield increases of about 1 t/ha were observed at each test site. The cost of the fertilizer was $39.20 while the application costs were $14.62 for a total cost of $53.82/ha. The extra return of forage in dollars was $82.50 minus the total costs of $53.82 for a profit of $28.68/ha. At the Driftwood and Pineview sites further gains were realized with higher N fertilizer rates of about 100 kg/ha. Fertilization with K and micronutrients is not economical except under special conditions such as the use of K in preventing winter kill in legumes. While no response was obtained in these trials, sulfur and boron could also be required as many deficient soils have been identified in the Central Interior of B.C. Soil testing should still be carried out every few years to determine if nutrients are deficient or declining to levels where they need to be boosted with fertilizer.

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Appendix A1. Notations used.

Ae	Soil horizon which has lost a lot of clay and is highly leached.
B	Boron
Bt	Soil horizon which has been enriched with clay often making it denser.
CP	Crude protein
CPY	Crude protein yield
Cut 1	First harvest of a crop
Cut 2	Second harvest of a crop
Cu	Copper
DM	Dry matter
DMD	Dry matter digestible
DMDY	Dry matter digestible yield
DMY	Dry matter yield
ha	Hectare
K	Potassium
K_2O	Potash or potassium oxide
kg	Kilogram
kg/ha	Kilogram per hectare
mg/kg	milligrams/kg is equal to parts per million
mm	Millimeter (1/1000 of a meter)
Mo	Molybdenum
P	Phosphorus
P_2O_5	Phosphoric acid or phosphorus oxide (fertilizer term)
ppm	parts per milion which is equal to mg/kg

Appendix A2. Some Conversion Factors for English and Metric Units.

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1 multiply by
	Length		
0.621	kilometer, km	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
0.394	centimeter, cm	inch, in	2.540
0.0394	millimeter, mm	inch, in	25.400
	Area		
2.471	hectare, ha	acre, A	0.405
	Mass		
1.102	tonne (metric), t	ton (English), T	0.9072
2.205	Kilogram, kg	pound, lb	0.454
	Yield		
0.446	tonne (metric)	ton (English)	2.242
0.892	kg/ha	lb/acre	1.121

Appendix B1. Temperature and precipitation data for Smithers.

Month	Monthly Means 1976	1977	1978	1979	Long Term Normal	%Difference From Normal 1976	1977	1978	1979
					Temperature (°C)				
Jan	-7.5	-8.6	-10.5	-14.0	-10.6	3.1	2.0	0.1	-3.4
Feb.	-5.7	-0.3	-4.7	-9.6	-5.2	-0.5	4.9	0.5	-4.4
Mar.	-2.6	-0.3	-0.7	1.9	-1.3	-1.3	1.0	0.6	3.2
Apr.	4.2	6.3	5.2	5.4	3.9	0.3	2.4	1.3	1.5
May	8.1	8.8	8.3	8.6	9.2	-1.1	-0.4	-0.9	-0.6
June	10.8	12.9	14.2	11.7	12.7	-1.9	0.2	1.5	-1.0
July	12.4	14.5	16.6	16.2	14.6	-2.2	-0.1	2.0	1.6
Aug.	13.6	17.0	14.7	16.4	13.8	-0.2	3.2	0.9	2.6
Sept.	10.7	9.1	9.2	11.1	10.0	0.7	-0.9	-0.8	1.1
Oct.	4.7	4.5	5.9	6.0	4.6	0.1	-0.1	1.3	1.4
Nov.	-0.3	-4.9	-4.5	-2.2	-2.2	1.9	-2.7	-2.3	0.0
Dec.	-4.3	-14.3	-8.3	-4.7	-7.5	3.2	-6.8	-0.8	2.8
					Total Precipitation (mm)				
Jan	78.0	47.1	14.0	35.0	55.4	22.6	-8.3	-41.4	-20.4
Feb.	27.4	25.6	21.4	41.5	30.1	-2.7	-4.5	-8.7	11.4
Mar.	33.0	31.7	11.7	11.3	23.7	9.3	8.0	-12.0	-12.4
Apr.	03.6	21.9	25.5	10.7	21.9	-18.3	0.0	3.6	-11.2
May	48.8	33.1	24.6	56.7	32.1	16.7	1.0	-7.5	24.6
June	58.9	30.2	25.0	23.0	40.3	18.6	-10.1	-15.3	-17.3
July	62.0	66.0	20.0	45.8	48.9	13.1	17.1	-28.9	-3.1
Aug.	41.1	47.7	94.2	32.8	39.4	1.7	8.3	54.8	6.6
Sept.	28.7	64.2	48.6	57.9	47.9	-19.2	16.3	0.7	10.0
Oct.	64.3	48.5	78.9	55.0	59.9	4.4	-11.4	19.0	-4.9
Nov.	30.2	53.3	87.2	7.0	56.1	-25.9	-2.8	31.1	-49.1
Dec.	64.5	34.5	34.2	43.5	56.6	7.9	-22.1	-22.4	-13.1

Appendix B2. Temperature and total precipitation data for Prince George.

	Monthly Means				Long Term	% Difference From Normal			
Month	1977	1978	1979	1980	Normal	1977	1978	1979	1980
					Temperature (°C)				
Jan.	-7.4	-12.7	-18.2	-13.4	-11.8	4.4	-0.9	-6.4	-1.6
Feb.	0.6	-5.0	-12.7	-4.2	-6.2	6.8	1.2	-6.5	2.0
Mar.	0.4	0.2	1.1	-2.2	-2.1	2.5	-2.3	3.2	-0.1
Apr.	6.7	6.0	4.1	7.0	3.9	2.8	2.1	0.2	3.1
May	9.3	8.6	8.7	10.7	9.4	-0.1	-0.8	-0.7	1.3
June	13.0	13.0	12.5	13.5	13.0	0.0	0.0	-0.5	0.5
July	14.1	17.0	16.0	14.3	14.9	-0.8	2.1	1.1	-0.6
Aug.	15.6	14.2	16.1	12.7	13.7	1.9	0.5	2.4	-1.0
Sept.	8.6	9.3	11.9	9.8	9.8	-1.2	-0.5	2.1	0.0
Oct.	5.2	6.3	6.1	6.2	4.7	0.5	1.6	1.4	1.5
Nov.	-4.5	-5.9	-3.3	1.0	-2.8	-1.7	-3.1	-0.5	3.8
Dec.	-14.3	-11.1	-5.8	-8.1	-7.6	-6.7	-3.5	1.8	-0.5
					Total Precipitation (mm)				
Jan.	0.0	29.2	25.9	18.3	59.2	-19.2	-30.0	-33.3	-40.9
Feb.	19.3	7.6	81.3	28.6	42.9	-23.6	-35.3	38.4	-14.3
Mar.	30.9	53.3	15.8	54.7	31.5	-0.6	21.8	-15.7	23.2
Apr.	26.5	18.4	18.4	22.4	29.5	-3.0	-11.1	-11.1	-7.1
May	65.0	44.5	71.6	65.9	42.2	22.8	2.3	29.4	23.7
June	54.3	37.0	72.6	84.4	58.2	-3.9	-21.2	-14.4	26.2
July	109.5	37.9	24.6	83.4	57.9	51.6	-20.0	-33.3	25.5
Aug.	52.2	62.8	31.7	106.2	73.4	-21.2	-10.6	-41.7	32.8
Sept.	65.8	52.4	50.2	85.3	55.9	9.9	-3.5	-5.7	29.4
Oct.	23.8	48.6	53.3	32.0	61.0	-37.2	-12.4	-7.7	-29.0
Nov.	36.0	46.1	2.8	19.1	54.9	-18.9	-8.8	-52.1	-35.8
Dec.	41.7	50.4	73.5	121.3	54.1	-12.4	-3.7	19.4	67.2

Appendix C1. Dry matter yield(DMY) in tonnes per hectare for the nitrogen rate trial.

Site	Cut	Year	Nitrogen rate (kg/ha) 0	56	112 (t/ha)*	168	224	336
Doughty	1	1976	3.15	3.85	4.15	4.05	3.96	3.51
	1	1977	2.59	3.93	3.27	3.34	3.79	3.46
	1	1978	1.72	2.78	2.75	3.17	3.23	2.60
	1	1979	3.38	3.93	4.19	4.13	3.96	3.74
		Mean	2.71	3.63	3.59	3.67	3.74	3.33
	2	1976	1.95	1.99	2.10	2.80	3.30	4.55
	2	1977	1.47	1.55	1.67	1.84	2.13	2.09
	2	1978	0.52	0.54	0.91	0.90	1.01	0.99
		Mean	1.31	1.36	1.56	1.85	2.15	2.54
	1+2	Mean	4.02	4.99	5.15	5.52	5.88	5.87
Driftwood	1	1976	3.84	4.71	4.96	5.32	5.23	5.61
	1	1977	3.86	4.48	5.52	4.87	5.02	5.08
	1	1978	1.60	2.29	2.57	2.97	2.82	3.18
	1	1979	2.11	3.18	3.54	3.82	3.60	3.44
		Mean	2.85	3.67	4.15	4.25	4.36	4.33
	2	1976	3.47	3.93	3.60	3.82	4.36	4.41
	2	1977	1.90	2.13	2.25	2.46	2.56	2.69
	2	1978	1.06	1.29	1.52	1.70	1.80	1.92
		Mean	2.14	2.45	2.46	2.66	2.91	3.00
	1+2	Mean	5.00	6.12	6.60	6.91	7.27	7.33
Pineview	1	1977	4.45	5.91	6.31	6.33	6.38	5.95
	1	1978	4.18	4.62	5.28	5.40	5.41	5.81
	1	1979	5.10	6.40	6.77	7.14	7.45	8.39
	1	1980	4.28	6.25	7.30	7.99	7.69	8.45
		Mean	4.50	5.80	6.42	6.72	6.73	7.15
	2	1977	2.51	2.13	2.71	3.61	4.40	4.83
	2	1978	1.13	1.02	1.10	1.01	1.16	1.30
	2	1980	1.36	1.25	1.46	2.04	2.70	3.56
		Mean	1.66	1.47	1.76	2.22	2.75	3.23
	1+2	Mean	6.17	7.27	8.18	8.94	9.49	10.38

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C2. Percent dry matter digestibility (DMD) data for the nitrogen rate trial.

Site	Cut	Year	0	56	112	168	224	336
			Nitrogen rate (kg/ha) (%)					
Doughty	1	1976	67.18	66.84	67.25	66.24	64.99	67.07
	1	1977	71.05	62.69	68.76	68.48	65.07	66.35
	1	1978	67.43	63.80	63.71	62.69	61.73	66.01
	1	1979	73.32	70.47	67.99	68.83	60.79	71.31
		Mean	69.75	65.95	66.93	66.56	63.14	67.69
	2	1976	71.85	68.37	71.30	70.28	66.65	60.65
	2	1977	62.42	58.26	60.54	59.76	55.83	55.22
	2	1978	73.79	70.76	73.94	71.20	70.68	71.04
		Mean	69.36	65.80	68.59	67.08	64.39	62.30
	1+2	Mean	69.55	65.88	67.76	66.82	63.77	65.00
Driftwood	1	1976	73.16	71.68	69.30	70.09	70.74	68.36
	1	1977	69.65	66.55	62.77	64.14	64.49	60.68
	1	1978	64.51	62.41	62.42	61.01	60.71	58.27
	1	1979	67.45	64.62	65.25	62.51	63.77	62.79
		Mean	68.69	66.31	64.94	64.44	64.93	62.52
	2	1976	66.95	65.74	59.83	63.31	61.55	57.75
	2	1977	60.53	60.49	57.89	60.23	59.10	57.33
	2	1978	72.45	70.46	68.14	67.15	66.51	63.65
		Mean	66.65	65.57	61.96	63.56	62.39	59.57
	1+2	Mean	67.67	65.94	63.45	64.00	63.66	61.05
Pineview	1	1977	65.53	60.65	58.30	57.79	59.04	59.80
	1	1978	68.45	64.86	62.05	60.02	58.92	56.88
	1	1979	59.25	56.07	53.64	47.13	46.99	40.81
	1	1980	57.30	55.05	52.16	48.51	45.52	42.77
		Mean	62.63	59.16	56.54	53.36	52.62	50.07
	2	1977	65.36	61.98	60.80	50.18	50.00	48.87
	2	1978	71.46	73.74	70.46	69.79	70.94	69.15
	2	1980	64.86	66.41	64.47	60.42	58.65	51.76
		Mean	67.23	67.37	65.24	60.13	59.86	56.60
	1+2	Mean	64.93	63.27	60.89	56.75	56.24	53.33

Note: 1979 cut 2 data not available as it was too dry.

Appendix C3. Dry matter digestible yield (DMDY) in tonnes per hectare for the nitrogen rate trial.

Site	Cut	Year	Nitrogen rate (kg/ha) 0	56	112	168 (t/ha)*	224	336
Doughty	1	1976	2.11	2.57	2.79	2.68	2.56	2.35
	1	1977	1.84	2.46	2.25	2.28	2.46	2.30
	1	1978	1.15	1.77	1.75	1.97	1.97	1.72
	1	1979	2.47	2.77	2.84	2.83	2.42	2.65
		Mean	1.89	2.40	2.41	2.44	2.36	2.26
	2	1976	1.39	1.35	1.50	1.97	2.20	2.76
	2	1977	0.92	0.91	1.01	1.10	1.18	1.15
	2	1978	0.38	0.38	0.68	0.64	0.71	0.70
		Mean	0.90	0.88	1.06	1.23	1.36	1.54
	1+2	Mean	2.79	3.28	3.47	3.68	3.72	3.80
Driftwood	1	1976	2.81	3.38	3.44	3.73	3.74	3.84
	1	1977	2.68	2.98	3.47	3.12	3.23	3.08
	1	1978	1.03	1.43	1.60	1.81	1.73	1.85
	1	1979	1.42	2.05	2.31	2.39	2.26	2.16
		Mean	1.99	2.46	2.71	2.76	2.89	2.73
	2	1976	2.33	2.58	2.15	2.42	2.68	2.55
	2	1977	1.15	1.29	1.30	1.48	1.51	1.55
	2	1978	0.77	0.91	1.03	1.14	1.20	1.22
		Mean	1.42	1.59	1.50	1.68	1.80	1.77
	1+2	Mean	3.40	4.06	4.20	4.44	4.69	4.51
Pineview	1	1977	2.90	3.59	3.68	3.66	3.77	3.57
	1	1978	2.87	2.99	3.27	3.24	3.18	3.31
	1	1979	3.02	3.58	3.63	3.36	3.50	3.44
	1	1980	2.42	3.44	3.79	3.85	3.48	3.57
		Mean	2.80	3.40	3.59	3.53	3.48	3.47
	2	1977	1.63	1.31	1.64	1.81	2.20	2.36
	2	1978	0.81	0.75	0.78	0.70	0.83	0.90
	2	1980	0.88	0.83	0.94	1.23	1.58	1.84
		Mean	1.11	0.97	1.12	1.25	1.54	1.70
	1+2	Mean	3.91	4.37	4.71	4.78	5.02	5.18

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C4. Percent crude protein (CP) data for nitrogen rate trial.

			Nitrogen rate (kg/ha)					
Site	Cut	Year	0	56	112	168 (%)	224	336
Doughty	1	1976	11.20	10.65	12.10	14.86	15.12	18.47
	1	1977	12.40	10.01	12.59	13.10	13.15	14.65
	1	1978	10.95	11.64	13.69	14.47	15.22	15.68
	1	1979	13.54	13.78	14.31	14.82	16.65	15.77
		Mean	12.02	11.52	13.17	14.31	15.03	16.14
	2	1976	15.88	14.02	14.58	12.26	9.31	10.61
	2	1977	16.47	14.11	15.41	14.67	12.91	14.05
	2	1978	20.52	18.86	20.43	22.33	22.81	25.37
		Mean	17.63	15.67	16.81	16.42	15.01	16.68
	1+2	Mean	14.83	13.59	14.99	15.37	15.02	16.41
Driftwood	1	1976	12.08	13.84	13.04	14.86	15.54	15.97
	1	1977	12.84	12.60	14.05	13.93	16.01	17.85
	1	1978	13.16	11.62	13.08	13.42	14.87	15.16
	1	1979	9.03	10.68	12.57	14.23	17.10	17.79
		Mean	11.78	12.19	13.19	14.11	15.88	16.69
	2	1976	12.72	12.25	10.87	9.68	9.83	9.11
	2	1977	11.34	9.72	9.27	9.31	10.28	12.03
	2	1978	14.25	13.55	13.59	13.79	15.79	17.88
		Mean	12.77	11.84	11.24	10.93	11.97	13.01
	1+2	Mean	12.27	12.01	12.22	12.52	13.93	14.85
Pineview	1	1977	13.13	10.65	12.00	13.74	14.75	15.66
	1	1978	15.99	14.31	13.31	12.86	13.57	14.85
	1	1979	11.38	10.20	10.08	9.76	10.60	10.97
	1	1980	10.16	8.95	9.05	10.72	11.11	12.16
		Mean	12.67	11.03	11.11	11.77	12.51	13.41
	2	1977	16.68	14.01	13.04	10.76	9.46	12.35
	2	1978	20.13	19.51	19.78	18.87	18.14	19.98
	2	1980	12.42	12.06	10.67	8.90	9.00	11.00
		Mean	16.41	15.19	14.50	12.84	12.20	14.45
	1+2	Mean	14.54	13.11	12.80	12.31	12.36	13.93

Note: 1979 cut 2 data not available as it was too dry.

Appendix C5. Crude protein yield (CPY) in tonnes per hectare for the nitrogen rate trial.

Site	Cut	Year	0	56	112	168	224	336
			Nitrogen rate (kg/ha)					
			(t/ha)*					
Doughty	1	1976	0.35	0.41	0.50	0.60	0.60	0.65
	1	1977	0.32	0.39	0.41	0.44	0.50	0.51
	1	1978	0.19	0.32	0.38	0.45	0.50	0.41
	1	1979	0.45	0.54	0.60	0.61	0.66	0.58
		Mean	0.33	0.42	0.47	0.52	0.56	0.53
	2	1976	0.30	0.27	0.30	0.34	0.31	0.48
	2	1977	0.24	0.22	0.26	0.27	0.27	0.29
	2	1978	0.10	0.10	0.18	0.20	0.23	0.25
		Mean	0.22	0.20	0.25	0.27	0.27	0.34
	1+2	Mean	0.54	0.62	0.72	0.80	0.83	0.88
Driftwood	1	1976	0.46	0.65	0.65	0.79	0.81	0.90
	1	1977	0.50	0.56	0.78	0.68	0.79	0.91
	1	1978	0.21	0.26	0.33	0.40	0.41	0.48
	1	1979	0.19	0.34	0.44	0.54	0.58	0.61
		Mean	0.34	0.45	0.55	0.60	0.68	0.73
	2	1976	0.44	0.48	0.39	0.37	0.42	0.40
	2	1977	0.22	0.21	0.21	0.23	0.26	0.32
	2	1978	0.15	0.17	0.20	0.23	0.29	0.34
		Mean	0.27	0.29	0.27	0.28	0.32	0.35
	1+2	Mean	0.61	0.74	0.82	0.88	1.00	1.08
Pineview	1	1977	0.59	0.63	0.76	0.87	0.94	0.93
	1	1978	0.67	0.66	0.70	0.69	0.73	0.86
	1	1979	0.58	0.65	0.68	0.69	0.79	0.92
	1	1980	0.43	0.57	0.65	0.84	0.85	1.01
		Mean	0.57	0.63	0.70	0.78	0.83	0.93
	2	1977	0.43	0.30	0.36	0.39	0.42	0.59
	2	1978	0.23	0.20	0.22	0.19	0.21	0.26
	2	1980	0.17	0.15	0.15	0.18	0.24	0.39
		Mean	0.27	0.22	0.24	0.25	0.29	0.41
	1+2	Mean	0.84	0.85	0.94	1.03	1.12	1.35

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C6. Dry matter yield (DMY) in tonnes per hectare for the split nitrogen trial.

			Nitrogen rate (kg/ha)					
			112			224		
Site	Year	Method	Cut 1	Cut 2	Total	Cut 1	Cut 2	Total
					(t/ha)*			
Doughty	1976	Single	4.15	2.10	6.25	3.96	3.30	7.40
	1976	Split	3.50	3.82	6.95	4.37	3.90	8.11
	1977	Single	3.27	1.67	4.94	3.79	2.13	5.82
	1977	Split	3.34	1.83	4.73	4.09	2.50	6.30
	1978	Single	2.75	0.91	3.66	3.23	1.01	4.18
	1978	Split	2.45	1.05	3.40	2.89	0.96	3.88
	1979	Single	4.19	na	4.19	3.96	na	3.96
	1979	Split	3.66	na	3.66	3.96	na	3.96
	Mean	Single	3.59	1.56	4.76	3.74	2.15	5.34
	Mean	Split	3.24	2.23	4.69	3.83	2.45	5.56
Driftwood	1976	Single	4.96	3.60	8.56	5.23	4.36	9.75
	1976	Split	4.69	4.62	9.32	5.31	5.70	11.01
	1977	Single	5.52	2.25	7.77	5.02	2.56	7.57
	1977	Split	4.70	2.93	7.63	5.20	3.05	8.25
	1978	Single	2.57	1.52	4.09	2.82	1.80	4.66
	1978	Split	2.16	2.01	4.17	3.03	2.27	5.31
	1979	Single	3.54	na	3.54	3.60	na	3.60
	1979	Split	3.34	na	3.34	3.41	na	3.41
	Mean	Single	4.15	2.46	5.99	4.36	2.91	6.40
	Mean	Split	3.72	3.19	6.12	4.24	3.67	7.00
Pineview	1977	Single	6.31	2.71	9.03	6.38	4.40	10.78
	1977	Split	6.16	3.95	10.11	6.68	4.69	11.38
	1978	Single	5.28	1.10	6.38	5.41	1.16	6.58
	1978	Split	4.65	1.28	5.93	5.36	1.70	7.07
	1979	Single	6.77	na	6.77	7.45	na	7.45
	1979	Split	6.22	na	6.22	7.18	na	7.18
	1980	Single	7.30	1.46	8.76	7.69	2.70	10.39
	1980	Split	6.27	2.91	9.18	7.63	4.06	11.69
	Mean	Single	6.42	1.76	7.74	6.73	2.75	8.80
	Mean	Split	5.83	2.71	7.86	6.72	3.49	9.33

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C7. Percent dry matter digestibility (DMD) data for split nitrogen trial.

			Nitrogen rate (kg/ha)					
			112			224		
Site	Year	Method	Cut 1	Cut 2	Average	Cut 1	Cut 2	Average
					(%)			
Doughty	1976	Single	67.25	71.30	69.28	64.99	66.65	66.02
	1976	Split	68.99	65.15	68.39	66.21	63.41	64.90
	1977	Single	68.76	60.54	64.65	65.07	55.83	61.14
	1977	Split	65.01	60.60	63.68	64.14	53.20	60.58
	1978	Single	63.71	73.94	68.83	61.73	70.68	67.72
	1978	Split	64.02	72.87	67.94	62.67	70.90	67.38
	1979	Single	67.99	na	na	60.79	na	na
	1979	Split	70.66	na	na	64.45	na	na
	Mean	Single	66.93	68.59	67.59	63.14	64.39	64.96
	Mean	Split	67.17	66.21	66.67	64.36	62.50	64.29
Driftwood	1976	Single	69.30	59.83	64.57	70.74	61.55	66.15
	1976	Split	71.13	62.88	67.01	69.99	57.09	63.54
	1977	Single	62.77	57.89	60.33	64.49	59.10	61.80
	1977	Split	64.83	58.45	61.64	60.28	56.64	58.46
	1978	Single	62.42	68.14	65.28	60.71	66.51	63.61
	1978	Split	59.71	67.31	63.51	59.07	66.77	62.92
	1979	Single	65.25	na	na	63.77	na	na
	1979	Split	61.56	na	na	62.93	na	na
	Mean	Single	64.94	61.96	63.39	64.93	62.39	63.85
	Mean	Split	64.31	62.88	64.05	63.07	60.17	61.64
Pineview	1977	Single	58.30	60.80	59.55	59.04	50.00	54.52
	1977	Split	58.07	54.43	56.25	60.17	45.76	52.97
	1978	Single	62.05	70.46	66.25	58.92	70.94	64.93
	1978	Split	61.95	71.88	66.91	57.08	68.84	62.96
	1979	Single	53.64	na	na	46.99	na	na
	1979	Split	53.96	na	na	48.06	na	na
	1980	Single	52.16	64.47	58.31	45.52	58.65	52.09
	1980	Split	51.17	59.13	55.15	46.77	48.84	47.81
	Mean	Single	56.54	65.24	61.37	52.62	59.86	57.18
	Mean	Split	56.29	61.81	59.44	53.02	54.48	54.58

Note: 1979 cut 2 data not available as it was too dry.

Appendix C8. Dry matter digestible yield (DMDY) in tonnes per hectare for split nitrogen trial.

			Nitrogen rate (kg/ha)					
			112			224		
Site	Year	Method	Cut 1	Cut 2	Total	Cut 1	Cut 2	Total
					(t/ha)*			
Doughty	1976	Single	2.79	1.50	4.29	2.56	2.20	4.86
	1976	Split	2.41	2.48	4.76	2.89	2.47	5.27
	1977	Single	2.25	1.01	3.26	2.46	1.18	3.62
	1977	Split	2.17	1.10	3.04	2.62	1.29	3.87
	1978	Single	1.75	0.68	2.43	1.97	0.71	2.68
	1978	Split	1.56	0.76	2.24	1.80	0.68	2.52
	1979	Single	2.84	na	2.84	2.42	na	2.42
	1979	Split	2.56	na	2.56	2.55	na	2.55
	Mean	Single	2.41	1.06	3.21	2.36	1.36	3.40
	Mean	Split	2.18	1.45	3.15	2.46	1.48	3.55
Driftwood	1976	Single	3.44	2.15	5.59	3.74	2.68	6.51
	1976	Split	3.34	2.91	6.25	3.71	3.26	6.98
	1977	Single	3.47	1.30	4.77	3.23	1.51	4.75
	1977	Split	3.04	1.71	4.76	3.13	1.73	4.86
	1978	Single	1.60	1.03	2.64	1.73	1.20	2.95
	1978	Split	1.29	1.35	2.64	1.79	1.52	3.31
	1979	Single	2.31	na	2.31	2.26	na	2.26
	1979	Split	2.06	na	2.06	2.14	na	2.14
	Mean	Single	2.71	1.50	3.83	2.89	1.80	4.12
	Mean	Split	2.43	1.99	3.93	2.70	2.17	4.32
Pineview	1977	Single	3.68	1.64	5.32	3.77	2.20	5.97
	1977	Split	3.57	2.15	5.72	4.02	2.15	6.17
	1978	Single	3.27	0.78	4.05	3.18	0.83	4.01
	1978	Split	2.88	0.92	3.80	3.06	1.17	4.23
	1979	Single	3.63	na	3.63	3.50	na	3.50
	1979	Split	3.35	na	3.35	3.48	na	3.48
	1980	Single	3.79	0.94	4.72	3.48	1.58	5.06
	1980	Split	3.20	1.71	4.92	3.56	1.98	5.55
	Mean	Single	3.59	1.12	4.43	3.48	1.54	4.64
	Mean	Split	3.25	1.59	4.45	3.53	1.77	4.86

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C9. Percent crude protein (CP) data for split nitrogen trial.

			Nitrogen rate (kg/ha)					
			112			224		
Site	Year	Method	Cut 1	Cut 2	Average	Cut 1	Cut 2	Average
					(%)			
Doughty	1976	Single	12.10	14.58	13.34	15.12	9.31	12.47
	1976	Split	11.70	9.67	10.77	12.37	10.32	11.32
	1977	Single	12.59	15.41	14.00	13.15	12.91	13.23
	1977	Split	10.32	12.53	11.96	11.58	13.47	12.95
	1978	Single	13.69	20.43	17.06	15.22	22.81	19.24
	1978	Split	11.36	21.06	16.37	13.28	24.28	19.47
	1979	Single	14.31	na	na	16.65	na	na
	1979	Split	11.62	na	na	14.02	na	na
	Mean	Single	13.17	16.81	14.80	15.03	15.01	14.98
	Mean	Split	11.25	14.42	13.04	12.81	16.03	14.58
Driftwood	1976	Single	13.04	10.87	11.96	15.54	9.83	12.68
	1976	Split	13.04	9.57	11.31	12.86	8.80	10.83
	1977	Single	14.05	9.27	11.66	16.01	10.28	13.15
	1977	Split	10.79	9.89	10.34	12.57	13.40	12.98
	1978	Single	13.08	13.59	13.34	14.87	15.79	15.33
	1978	Split	10.91	14.96	12.94	12.33	18.47	15.40
	1979	Single	12.57	na	na	17.10	na	na
	1979	Split	9.86	na	na	13.54	na	na
	Mean	Single	13.19	11.24	12.32	15.88	11.97	13.72
	Mean	Split	11.15	11.47	11.53	12.82	13.56	13.07
Pineview	1977	Single	12.00	13.04	12.52	14.75	9.46	12.11
	1977	Split	10.61	10.49	10.55	12.50	10.70	11.60
	1978	Single	13.31	19.78	16.54	13.57	18.14	15.86
	1978	Split	12.12	19.37	15.75	11.12	20.12	15.62
	1979	Single	10.08	na	na	10.60	na	na
	1979	Split	8.53	na	na	8.28	na	na
	1980	Single	9.05	10.67	9.86	11.11	9.00	10.06
	1980	Split	8.58	8.72	8.65	10.94	10.14	10.54
	Mean	Single	11.11	14.50	12.97	12.51	12.20	12.67
	Mean	Split	9.96	12.86	11.65	10.71	13.65	12.59

Note: 1979 cut 2 data not available as it was too dry.

Appendix C10. Crude protein yield (CPY) in tonnes per hectare for the split nitrogen trial.

			Nitrogen rate (kg/ha) 112			224		
Site	Year	Method	Cut 1	Cut 2	Total	Cut 1	Cut 2	Total
					(t/ha)*			
Doughty	1976	Single	0.50	0.30	0.81	0.60	0.31	0.94
	1976	Split	0.41	0.37	0.75	0.55	0.40	0.93
	1977	Single	0.41	0.26	0.67	0.50	0.27	0.77
	1977	Split	0.35	0.22	0.53	0.47	0.33	0.78
	1978	Single	0.38	0.18	0.56	0.50	0.23	0.72
	1978	Split	0.28	0.22	0.48	0.38	0.24	0.64
	1979	Single	0.60	na	na	0.66	na	na
	1979	Split	0.42	na	na	0.56	na	na
	Mean	Single	0.47	0.25	0.68	0.56	0.27	0.81
	Mean	Split	0.37	0.27	0.59	0.49	0.32	0.78
Driftwood	1976	Single	0.65	0.39	1.04	0.81	0.42	1.23
	1976	Split	0.61	0.44	1.05	0.68	0.50	1.18
	1977	Single	0.78	0.21	0.99	0.79	0.26	1.06
	1977	Split	0.50	0.29	0.79	0.66	0.40	1.06
	1978	Single	0.33	0.20	0.54	0.41	0.29	0.70
	1978	Split	0.24	0.30	0.54	0.37	0.42	0.79
	1979	Single	0.44	na	na	0.58	na	na
	1979	Split	0.33	na	na	0.46	na	na
	Mean	Single	0.55	0.27	0.86	0.68	0.32	1.03
	Mean	Split	0.42	0.34	0.79	0.54	0.44	1.01
Pineview	1977	Single	0.76	0.36	1.12	0.94	0.42	1.36
	1977	Split	0.65	0.41	1.06	0.83	0.50	1.33
	1978	Single	0.70	0.22	0.92	0.73	0.21	0.95
	1978	Split	0.56	0.25	0.81	0.59	0.34	0.94
	1979	Single	0.68	na	na	0.79	na	na
	1979	Split	0.53	na	na	0.59	na	na
	1980	Single	0.65	0.15	0.81	0.85	0.24	1.09
	1980	Split	0.54	0.25	0.79	0.83	0.41	1.24
	Mean	Single	0.70	0.24	0.95	0.83	0.29	1.13
	Mean	Split	0.57	0.30	0.89	0.71	0.42	1.17

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C11. Dry matter yield (DMY) in tonnes per hectare for the minus trial.

Site	Cut	Year	Treatment -N	-P	-K (t/ha)*	Complete	+Micro-Nutrients
Doughty	1	1976	3.43	3.77	5.38	5.53	4.97
	1	1977	2.67	3.07	4.38	4.43	4.48
	1	1978	2.61	2.95	3.94	4.78	4.69
	1	1979	4.32	4.50	4.67	5.08	5.3
	1	Mean	3.26	3.57	4.59	4.96	4.87
	2	1976	2.44	3.22	3.17	3.10	3.00
	2	1977	1.66	1.86	1.87	2.03	2.60
	2	1978	0.89	1.06	1.17	1.15	1.26
	2	Mean	1.66	2.05	2.07	2.09	2.29
	1+2	Mean	4.92	5.62	6.67	7.05	7.16
Driftwood	1	1976	3.91	5.51	5.73	5.50	5.82
	1	1977	4.55	5.40	5.68	6.25	5.16
	1	1978	2.38	3.55	3.66	3.85	4.17
	1	1979	2.81	4.42	4.50	4.78	4.61
	1	Mean	3.41	4.72	4.90	5.09	4.94
	2	1976	4.20	4.12	4.31	4.39	4.44
	2	1977	2.18	2.65	2.77	2.74	2.86
	2	1978	1.38	1.98	1.97	2.04	2.16
	2	Mean	2.59	2.92	3.02	3.06	3.16
	1+2	Mean	6.00	7.64	7.92	8.16	8.10
Pineview	1	1977	4.91	6.57	5.72	6.30	6.39
	1	1978	4.51	5.46	5.58	5.83	5.58
	1	1979	5.54	6.72	7.30	7.38	7.28
	1	1980	4.93	8.33	8.51	9.80	9.10
	1	Mean	4.97	6.77	6.78	7.33	7.09
	2	1977	2.43	3.64	4.27	3.99	4.05
	2	1978	1.21	1.07	1.17	1.31	1.31
	2	1980	1.61	2.57	2.92	2.69	2.70
	2	Mean	1.75	2.43	2.79	2.66	2.69
	1+2	Mean	6.72	9.20	9.56	9.99	9.78

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C12. Percent dry matter digestibility (DMD) for the minus trial.

Site	Cut	Year	Treatment -N	-P	-K (%)	Complete	+Micro-Nutrients
Doughty	1	1976	69.96	65.94	64.18	60.41	65.01
	1	1977	68.65	67.85	63.13	61.84	63.01
	1	1978	65.13	64.88	59.85	60.24	59.63
	1	1979	70.31	68.14	60.05	63.20	61.37
	1	Mean	68.51	66.70	61.80	61.42	62.26
	2	1976	72.52	64.97	67.30	64.55	65.68
	2	1977	58.43	61.05	52.52	54.70	54.88
	2	1978	74.97	73.06	67.95	68.55	68.04
	2	Mean	68.64	66.36	62.59	62.60	62.86
	1+2	Mean	68.58	66.53	62.20	62.01	62.56
Driftwood	1	1976	72.88	69.14	68.90	70.61	66.33
	1	1977	67.79	61.72	61.95	62.85	61.17
	1	1978	62.37	59.77	58.80	60.11	59.46
	1	1979	67.11	64.80	58.43	61.88	60.24
	1	Mean	67.54	63.86	62.02	63.86	61.80
	2	1976	66.54	61.07	61.49	60.94	62.96
	2	1977	60.59	61.49	57.32	58.53	59.91
	2	1978	72.49	66.35	63.93	66.49	67.08
	2	Mean	66.54	62.97	60.92	61.99	63.32
	1+2	Mean	67.04	63.42	61.47	62.93	62.56
Pineview	1	1977	63.29	56.38	58.49	59.08	57.91
	1	1978	67.35	55.78	58.60	57.70	57.15
	1	1979	57.45	45.30	48.30	43.57	42.73
	1	1980	58.09	46.63	45.42	45.13	43.97
	1	Mean	61.55	51.02	52.71	51.37	50.44
	2	1977	62.04	48.21	50.19	54.26	45.54
	2	1978	71.00	68.37	68.49	57.69	63.33
	2	1980	63.92	58.14	56.61	59.28	55.73
	2	Mean	65.65	58.24	58.43	60.41	54.87
	1+2	Mean	63.60	54.64	55.57	55.89	52.66

Note: 1979 cut 2 data not available as it was too dry.

Appendix C13. Dry matter digestible yield (DMDY) in tonnes per hectare for the minus trial.

Site	Cut	Year	Treatment -N	-P	-K (t/ha)*	Complete	+Micro-Nutrients
Doughty	1	1976	2.40	2.48	3.45	3.34	3.23
	1	1977	1.84	2.08	2.77	2.73	2.83
	1	1978	1.69	1.91	2.35	2.88	2.79
	1	1979	3.03	3.06	2.80	3.21	3.27
	1	Mean	2.24	2.38	2.84	3.04	3.03
	2	1976	1.77	2.09	2.13	2.00	1.97
	2	1977	0.96	1.14	0.98	1.11	1.42
	2	1978	0.67	0.77	0.79	0.78	0.86
	2	Mean	1.13	1.33	1.30	1.30	1.42
	1+2	Mean	3.37	3.72	4.15	4.34	4.45
Driftwood	1	1976	2.85	3.81	3.95	3.88	3.87
	1	1977	3.09	3.33	3.53	3.93	3.16
	1	1978	1.49	2.12	2.15	2.32	2.47
	1	1979	1.88	2.86	2.63	2.96	2.78
	1	Mean	2.33	3.03	3.07	3.27	3.07
	2	1976	2.79	2.51	2.65	2.68	2.79
	2	1977	1.32	1.63	1.59	1.60	1.71
	2	1978	1.00	1.31	1.26	1.36	1.45
	2	Mean	1.70	1.82	1.84	1.88	1.99
	1+2	Mean	4.03	4.85	4.90	5.15	5.06
Pineview	1	1977	3.10	3.69	3.34	3.72	3.70
	1	1978	3.04	3.05	3.27	3.36	3.19
	1	1979	3.18	3.04	3.52	3.20	3.12
	1	1980	2.83	3.89	3.86	4.41	3.97
	1	Mean	3.04	3.42	3.50	3.67	3.49
	2	1977	1.48	1.75	2.13	2.17	1.85
	2	1978	0.85	0.73	0.80	0.89	0.82
	2	1980	1.03	1.49	1.65	1.59	1.50
	2	Mean	1.12	1.33	1.53	1.55	1.39
	1+2	Mean	4.16	4.75	5.03	5.22	4.89

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A

Appendix C14. Percent crude protein (CP) for minus the trial.

Site	Cut	Year	-N	-P	-K (%)	Complete	+Micro-Nutrients
Doughty	1	1976	12.70	15.20	14.69	14.46	14.08
	1	1977	13.21	13.49	14.74	14.20	14.78
	1	1978	12.67	14.60	16.51	15.29	16.32
	1	1979	17.48	14.65	16.32	15.75	13.48
	1	Mean	14.02	14.49	15.57	14.92	14.67
	2	1976	18.04	10.62	12.89	13.43	12.89
	2	1977	17.40	14.96	15.46	14.24	13.77
	2	1978	24.01	23.91	19.10	20.41	19.59
	2	Mean	19.82	16.50	15.82	16.03	15.42
	1+2	Mean	16.92	15.49	15.69	15.48	15.04
Driftwood	1	1976	15.43	15.58	16.02	15.50	15.58
	1	1977	12.90	15.10	16.45	16.56	14.73
	1	1978	12.04	13.49	14.65	14.26	14.54
	1	1979	9.74	14.04	15.67	14.96	14.79
	1	Mean	12.53	14.55	15.70	15.32	14.91
	2	1976	15.62	9.18	9.85	10.23	9.57
	2	1977	10.74	9.50	9.70	9.38	9.23
	2	1978	14.15	13.54	14.87	13.09	13.80
	2	Mean	13.50	10.74	11.47	10.90	10.87
	1+2	Mean	13.02	12.65	13.58	13.11	12.89
Pineview	1	1977	11.72	13.91	14.61	14.92	15.69
	1	1978	16.36	13.52	13.80	13.76	14.41
	1	1979	11.14	8.72	9.31	10.37	9.84
	1	1980	11.89	10.95	11.03	10.27	9.60
	1	Mean	12.78	11.78	12.19	12.33	12.39
	2	1977	16.41	9.89	8.91	9.58	9.70
	2	1978	20.32	17.39	17.94	17.50	18.55
	2	1980	13.81	8.52	8.33	8.20	8.73
	2	Mean	16.85	11.93	11.73	11.76	12.33
	1+2	Mean	14.82	11.86	11.96	12.05	12.36

Note: 1979 cut 2 data not available as it was too dry.

Appendix C15. Crude protein yield (CPY) in tonnes per hectare for the minus trial.

Site	Cut	Year	Treatment -N	-P	-K (t/ha)*	Complete	+Micro-Nutrient
Doughty	1	1976	0.43	0.57	0.79	0.80	0.69
	1	1977	0.35	0.41	0.65	0.63	0.66
	1	1978	0.33	0.43	0.65	0.73	0.76
	1	1979	0.76	0.67	0.77	0.80	0.70
	1	Mean	0.47	0.52	0.71	0.74	0.70
	2	1976	0.44	0.33	0.40	0.42	0.38
	2	1977	0.29	0.28	0.28	0.29	0.35
	2	1978	0.21	0.25	0.22	0.23	0.24
	2	Mean	0.31	0.29	0.30	0.31	0.33
	1+2	Mean	0.79	0.81	1.02	1.05	1.03
Driftwood	1	1976	0.60	0.85	0.92	0.85	0.90
	1	1977	0.59	0.81	0.94	1.04	0.76
	1	1978	0.28	0.47	0.53	0.55	0.60
	1	1979	0.27	0.62	0.70	0.71	0.69
	1	Mean	0.44	0.69	0.77	0.79	0.74
	2	1976	0.65	0.38	0.42	0.45	0.43
	2	1977	0.23	0.25	0.27	0.25	0.26
	2	1978	0.19	0.27	0.29	0.26	0.29
	2	Mean	0.36	0.30	0.33	0.32	0.33
	1+2	Mean	0.80	0.99	1.10	1.11	1.07
Pineview	1	1977	0.58	0.92	0.84	0.94	1.00
	1	1978	0.74	0.74	0.77	0.80	0.81
	1	1979	0.62	0.59	0.68	0.78	0.72
	1	1980	0.58	0.90	0.94	1.01	0.87
	1	Mean	0.63	0.79	0.81	0.88	0.85
	2	1977	0.40	0.36	0.38	0.38	0.39
	2	1978	0.25	0.18	0.21	0.23	0.24
	2	1980	0.22	0.22	0.24	0.22	0.23
	2	Mean	0.29	0.25	0.28	0.28	0.29
	1+2	Mean	0.92	1.04	1.08	1.16	1.14

Note: 1979 cut 2 data not available as it was too dry.
*t/ha * 0.446 = T/A